

**Digital Curation:
Contributions Towards
Defining the Discipline**

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Thesis submitted in fulfilment of the requirements for the degree of
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Declaration and statements

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| Word Count of thesis: | 91073 |
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STATEMENT 1

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Thesis summary

This work defines and evaluates the original contributions to the discipline of digital curation that the author has made through ten years of her career for the purposes of gaining a PhD by Published Works. It presents ten published papers, three of which are co-authored, and a narrative concerning the contributions made by these. This narrative explains the professional and academic contexts in which the papers were authored and the impact they have made. The work describes the progressive contributions to both the professional and academic development of the discipline through: an historical analysis of its origins, analysis of the conceptual space it inhabits, theoretical modelling of this conceptual space to enable practical implementations, and the development of higher education curricula. The work reflects on the disciplinary significance of these contributions and suggests next-steps for the author's research.

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- The collegiate working and intellectual input of my co-authors represented in 3 of the papers presented in this work: Jenny Bunn (Information Studies, UCL), Lyn Lewis Dafis (formerly National Library of Wales), Elizabeth Fairley (EFB Services), Christopher Hilton (Britten-Pears Foundation, formerly Wellcome Trust) and Angus Whyte (Digital Curation Centre);
- The help and advice of my supervisor Dr Pauline Rafferty;
- Funding from Information Studies at Aberystwyth University to attend the *Memory of the World in the Digital Age: Digitization and Preservation Conference* (2012) to deliver Paper 2; and the Aberystwyth University Conference Fund to attend the *International Council on Archives Conference* (2014) to deliver Paper 3.
- The support of my family – Chris, Teal and Jack the dog – especially the sterling work to ensure a peaceful and water-tight shed to work in.

Many thanks to all!



Dedication



Dedicated to my fellow pioneers at the Digital Curation Centre who inspired, instructed, shared and encouraged; especially Chris Rusbridge who led the team fairly and collaboratively to ensure both the Project and individual staff realised their potential.

Table of contents

| | |
|---|------|
| Declaration and statements | i |
| Thesis summary | ii |
| Acknowledgements | iii |
| Dedication..... | iv |
| Table of contents | v |
| List of figures..... | vii |
| List of tables..... | viii |
| Abbreviations used | x |
| Definitions..... | xi |
| 1. Introduction..... | 1 |
| 1.1 Introduction to digital curation..... | 1 |
| 1.2 The nature of a discipline..... | 2 |
| 1.3 Information science as a discipline | 6 |
| 1.4 Curation in information science..... | 12 |
| 1.5 Digital information – the new paradigm..... | 14 |
| 1.6 Positioning the research | 18 |
| 1.7 Limitations of the work | 19 |
| 1.8 A note about definitions | 19 |
| 2. Contributions to knowledge..... | 20 |
| 2.1 Main contributions..... | 20 |
| 2.2 Research conclusions | 21 |
| 2.3 Representative contributions and conclusions..... | 22 |
| 3. Details on contributions to knowledge | 23 |
| 3.1 Paper 1: <i>Digital Curation: The emergence of a new discipline</i> (2011) | 24 |
| 3.2 Paper 2: <i>Digital curation: The challenge driving convergence across memory institutions</i> (2013) | 24 |

| | | |
|------|---|----|
| 3.3 | Paper 3: <i>Archives context and discovery: rethinking arrangement and description for the digital age</i> (2014) | 25 |
| 3.4 | Paper 4: <i>Draft DCC Curation Lifecycle Model</i> (2007) | 26 |
| 3.5 | Paper 5: <i>The DCC Curation Lifecycle Model</i> (2008)..... | 26 |
| 3.6 | Paper 6: <i>Curated databases in the life sciences: The Edinburgh Mouse Atlas Project</i> (2009)..... | 28 |
| 3.7 | Paper 7: <i>DCC DIFFUSE standards frameworks. A standards path through the curation lifecycle</i> (2009)..... | 29 |
| 3.8 | Paper 8: <i>The lifecycle of data management</i> (2012) | 29 |
| 3.9 | Paper 9: <i>Data modelling for analysis, discovery and retrieval</i> (2016) | 30 |
| 3.10 | Paper 10: <i>Mainstreaming Digital Curation: An overview of activity in the UK archives and records management profession</i> (2013)..... | 31 |
| 4. | Discussion on contributions to knowledge | 33 |
| 4.1 | Papers 1-3: Exploring digital curation as a discipline..... | 34 |
| 4.2 | Papers 4 and 5: Developing the conceptual model | 37 |
| 4.3 | Paper 6 and 7: Testing and applying the conceptual model..... | 46 |
| 4.4 | Papers 8 and 9: Elaborating the conceptual model..... | 55 |
| 4.5 | Paper 10: Developing the digital curation curriculum | 58 |
| 4.6 | Contributions to academic research..... | 60 |
| 5. | Reflection and next steps | 63 |
| 5.1 | Improving discovery of digital archives | 63 |
| 5.2 | Testing and extending the DCC:CLM..... | 64 |
| 5.3 | Professionalising the discipline | 65 |
| 5.4 | Conclusion..... | 66 |
| 6. | Bibliography..... | 67 |
| 7. | Appendices | 80 |
| | Appendix A: List of submitted published works | 80 |
| | Appendix B: Pre-print text of the submitted published works..... | 82 |

| | | |
|------|---|----|
| B.1 | Paper 1: Digital Curation: The emergence of a new discipline | 82 |
| B.2 | Paper 2: Digital curation: The challenge driving convergence across memory institutions | 83 |
| B.3 | Paper 3: Archives context and discovery: rethinking arrangement and description for the digital age | 84 |
| B.4 | Paper 4: Draft DCC curation lifecycle model..... | 85 |
| B.5 | Paper 5: The DCC curation lifecycle model | 86 |
| B.6 | Paper 6: Curated databases in the life sciences: The Edinburgh Mouse Atlas Project..... | 87 |
| B.7 | Paper 7: DCC DIFFUSE standards frameworks. A standards path through the curation lifecycle | 88 |
| B.8 | Paper 8: The lifecycle of data management | 89 |
| B.9 | Paper 9: Data modelling for analysis, discovery and retrieval..... | 90 |
| B.10 | Paper 10: Mainstreaming Digital Curation: An overview of activity in the UK archives and records management profession..... | 91 |
| | Appendix C: Co-author signed declarations | 92 |
| | Appendix D: List of activities surrounding the published works | 92 |
| | Appendix E: Curriculum Vitae | 92 |

List of figures

| | |
|---|----|
| Figure 1-1: The developmental stages of a discipline (after Bawden & Robinson, 2012; Krishnan, 2009) | 3 |
| Figure 1-2: Characterisation of academic disciplines (after Becher & Trowler, 2001, p.36) | 5 |
| Figure 1-3: The academic to professional feedback loop of a professionally orientated discipline (after Cohen & Lloyd, 2014; Eastwood, 1994; Krishnan, 2009)..... | 6 |
| Figure 1-4: Slamecka's typology of information theories (1968) | 8 |
| Figure 1-5: The academic and professional focus of information science (after Capurro & Hjørland 2003) | 9 |
| Figure 1-6: A conceptual framework for the information science domain (adapted from Zins, 2007)..... | 10 |

| | |
|---|----|
| Figure 1-7: Robinson and Karamuftuoglu's model for information science (2010) with lifecycle components from Borko (1968) | 11 |
| Figure 1-8: The generic facets of information science sub-disciplines (after Bates, 2015) | 12 |
| Figure 1-9: Zins' model applied to digital curation (after Zins, 2007) | 14 |
| Figure 1-10: Bates' model mapped to digital curation (Bates, 2015) | 15 |
| Figure 1-11: Digital curation as a sub-meta-discipline of information science | 17 |
| Figure 4-1: Author's themes explored and their contribution summarised..... | 33 |
| Figure 4-2: Poster presented at the International Council on Archives Conference 2015 (Higgins & Hilton, 2015)..... | 36 |
| Figure 4-3: The digital resource lifecycle (after Beagrie & Greenstein, 1998 and Feeney, 1999) | 38 |
| Figure 4-4: Drafts 1 and 2 of the DCC Curation Lifecycle Model | 42 |
| Figure 4-5: Drafts 3 and 4 of the DCC Curation Lifecycle Model | 43 |
| Figure 4-6: Drafts 5 and 6 of the DCC Curation Lifecycle Model | 44 |
| Figure 4-7: Drafts 7 and 8 of the DCC Curation Lifecycle Model | 45 |
| Figure 4-8: Google Scholar citations to the DCC Curation Lifecycle Model..... | 49 |
| Figure 4-9: Research training materials (Portsmouth University Postgraduate Online Research Training, 2013)..... | 50 |
| Figure 4-10: Planning software development (Eckard, Pillen, & Shallcross, 2017) | 50 |
| Figure 4-11: Planning research data management services (J. Lee, 2016)..... | 50 |
| Figure 4-12: Recent mentions of the DCC:CLM on Twitter (1) | 51 |
| Figure 4-13: Recent mentions of the DCC:CLM on Twitter (2) | 52 |
| Figure 4-14: Policy advice gap analysis for the DCC (Jones, 2008) | 55 |
| Figure 4-15: Iteratively identifying the digital curation curriculum (Bunn & Higgins, 2013; Higgins, 2008; Karvelyte et al., 2012; Pomerantz, Wildemuth, et al., 2009; Williams, 2012)..... | 59 |

List of tables

| | |
|---|----|
| Table 3-1: Contributions to digital curation's disciplinary development by the papers submitted..... | 23 |
| Table 4-1: Warwick Workshops: Recommendations on defining digital curation activities | 37 |
| Table 4-2: The development timeline for the DCC Curation Lifecycle Model..... | 41 |
| Table 4-3: Warwick Workshops: Recommendations for case study development..... | 47 |

| | |
|---|----|
| Table 4-4: Examples of DCC:CLM implementations in 2008-2009 (after Higgins, 2009) | 48 |
| Table 4-5: Warwick Workshops: Recommendations for development of a tools register | 53 |
| Table 4-6: Number of citations to each paper listed by date of publication..... | 61 |
| Table A.7-1: List of submitted published works cross referenced to section..... | 81 |

Abbreviations used

| | |
|-----------|--|
| ARA | Archives and Records Association |
| ARA SAT | Archives and Records Association Section for Archives and Technology |
| CILIP | Chartered Institute of Library and Information Professionals (The Library and Information Association) |
| COPTR | Community Owned Digital Preservation Tool Registry |
| DAF | Data Asset Framework |
| DC 101 | Digital Curation 101 |
| DCC | Digital Curation Centre |
| DCC:CLM | DCC Curation Lifecycle Model |
| DigCurV | Digital Curator Vocational Education Europe Project |
| DMPonline | Data Management Plans Online |
| DPC | Digital Preservation Coalition |
| DRAMBORA | Digital Repository Audit Method Based on Risk Assessment |
| EMAP | Edinburgh Mouse Atlas Project |
| IASSIST | International Association for Social Science Information Services and Technology |
| ICA | International Council on Archives |
| IDCC | International Digital Curation Conference |
| ISO | International Organization for Standardization |
| JCDL | Joint Conference on Digital Libraries |
| JISC | Joint Information Systems Committee |
| LAMs | Libraries, Archives and Museums |
| MALD | Welsh Government Department of Museums, Archives and Libraries |
| MoReq2 | Model Requirements for the Management of Electronic Records, 2 nd edition |
| OAIS | Reference Model for an Open Archival Information System (ISO 14721) |
| RiC-CM | Records in Context Conceptual Model |
| RORRI | DCC Registry Repository of Representation Information |
| UCL | University College London |
| UK | United Kingdom |
| US | United States of America |

Definitions

| | |
|--------------------------------------|---|
| Born-digital | Digital material that has been created digitally and primary access and use is designed to be through computer hardware and software. |
| Digital curation | The ecology of technical, administrative and financial activities that ensure access to a preserved bit-stream over the long-term. |
| Digital preservation | Specific preservation actions that intervene to ensure the survival of a digital bit-stream. |
| Preservation of electronic materials | A now mostly disused term for digital preservation popular in the archives and records management disciplines in the late 1990s. |

1. Introduction

This work presents a selection of ten of the author's works published since 2007, along with a narrative surrounding their contribution to knowledge in the field of information science, with the purpose of achieving a *PhD by Published Works*.

The regulations under which this work is submitted require the author to:

'Give an evaluation of the field in which you have worked indicating the original contribution to learning in that field which, in your opinion, your work has made.'

(Aberystwyth University Academic Quality and Records Office,
2013)

The works presented have been chosen to represent a general research theme surrounding the modern imperative to identify activities and workflow for curating information created digitally, so that it can remain useable and accessible over the long-term. They address the author's distinct contribution to the conceptual development of digital curation as a separate and discrete academic discipline within the information science domain, with an emphasis on conceptual modelling to inform implementation and the development of professional education in the arena.

1.1 Introduction to digital curation

With the embedding of personal computers and hand-held devices into modern society digital information has become ubiquitous, reaching into every aspect of our personal and professional lives. Digital curation is a new discipline that addresses the technical, administrative and financial ecology required to maintain access to digital material through organisational and technical changes over the long-term (Abbott, 2008; Digital Curation Centre, 2005a; Higgins, 2011; Kim, Warga, & Moen, 2013, p.67; Pennock, 2007; Tibbo, 2012 pp. 2-3; Tibbo & Lee, 2010, p.126).

Initially regarded as a narrow technical field, the organisational problem of preserving digital information came to the fore in the mid-1990s (Hedstrom, 1998; Ross, 2000).

Action in the UK was spearheaded by the Joint Information Systems Committee (JISC)¹ whose funded activities led to the establishment of the Digital Preservation Coalition (DPC)² in 2001 and Digital Curation Centre (DCC)³ in 2004 (Higgins, 2011). These organisations were charged with developing a specialist professional community for practitioners caring for digital materials through co-ordinated support; and raising awareness, providing resources and leading research in the area (Digital Curation Centre, 2004a). At its inception the DCC struggled to define the remit and boundaries of digital curation (Kerr, Reddington, & Wilkinson, 2005) finding very quickly that a robust conceptual definition of what it entailed was required to provide a focus for their training and resource provision activities (Digital Curation Centre, 2004b, 2005a, 2005b).

1.2 The nature of a discipline

In his critique of capitalist society Foucault identified that disciplinary methods are adopted 'in response to particular needs' (Foucault, 1975, p138) as societies and economies change and develop. He identified that a *disciplinary society* adopts techniques for assuring order and embedding power structures by enclosing and organising analytical spaces. Although critical of the use of discipline to maintain power positions and feed the state, his work illuminates how these organised analytical spaces become academic disciplines through rigorous pedagogical organisation, the development of hierarchies of specialisation, and stages of increasing difficulty through which individuals need to progress to master the subject (Foucault, 1975). Detailed characterisation, classification and specialisation develop firm foundations to embed disciplines as distinct knowledge bases, with contextualised research theories and methods, and acknowledged scholars (Cohen & Lloyd, 2014; Dirks, 1996; Foucault, 1975; Schommer-Aikins, Duell, & Barker, 2003).

¹ Joint Information Systems Committee (JISC): <https://www.jisc.ac.uk/>

² Digital Preservation Coalition (DPC): <http://www.dpconline.org/>

³ Digital Curation Centre (DCC): <http://www.dcc.ac.uk/>

‘The disciplines characterize, classify, specialize; they distribute along a scale, around a norm, hierarchize individuals in relation to one another and, if necessary, disqualify and invalidate.’

(Foucault, 1975, p.223)

Krishnan (2009, p.9) identifies six stages that progress in a linear fashion to the mature definition of a discipline: a particular object of research, a body of accumulated specialist knowledge, theories and concepts to effectively organise this specialist knowledge, specific language, specific research methods and institutional recognition through university or college level education. Bawden and Robinson (2012, p.10) note the foundation of representative professional bodies as the first sign of public recognition (Figure 1-1).

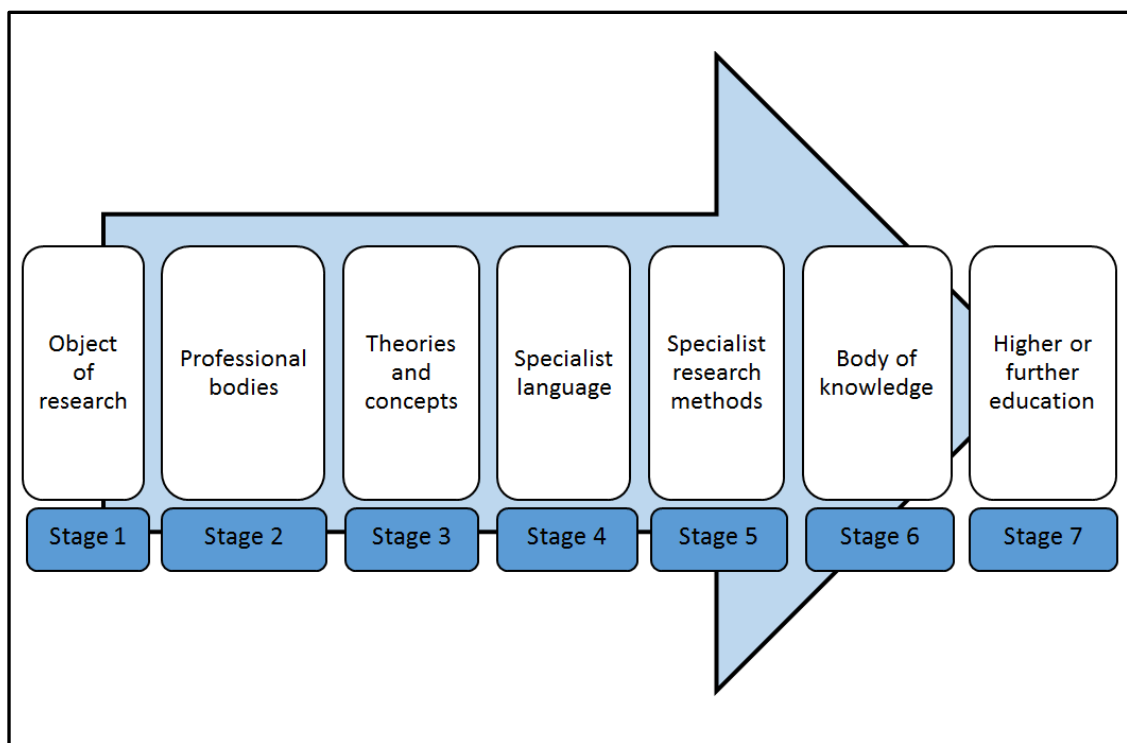


Figure 1-1: The developmental stages of a discipline (after Bawden & Robinson, 2012; Krishnan, 2009)

The common understanding of specialist knowledge surrounding an academic discipline is inherited and entrenched through learning and teaching (Cohen & Lloyd, 2014). The boundaries being drawn-up and protected through the coherence of their theories and the development of tacit or encoded rules regarding acceptable truth (Foucault, 1975); giving its proponents a safe cultural identity through shared discourse and epistemology. This safe cultural identity is further protected through rigid organisational and educational structures that cannot be endorsed outside the group, so that disciplines can become isolated silos (Gill, 2013; Krishnan, 2009).

However disciplines need to fulfil societal needs which are not static; so they continue to develop through research in *continuous evolutions* while individuals find their own *genesis* within the discipline (Foucault, 1975, pp.160-161). These societal *evolutions* and personal *geneses* can lead to the identification of anomalies in accepted underlying theories and methods so that, to solve these, the whole discipline changes its theoretical and methodological framework in a paradigm shift (Kuhn, 1962). Less radical are incremental changes in disciplines as new research brings forward new solutions so that variations occur. If variations become pronounced then new disciplines may develop through *speciation* ‘the division of a single discipline into two or more *genetically* similar but distinct ones’ (Cohen & Lloyd, 2014, p.194). Meanwhile parallel disciplinary developments may combine through interdisciplinary activities to create a new hybrid discipline with distinct features from both. Practically orientated disciplines may in fact be multi-hybrid or multi-disciplinary, drawing on a number of different disciplines that shed light on their primary object of research (Bawden & Robinson, 2012; Hirst, 1974). A meta-discipline may develop if the object of research cuts across and draws on a number of disciplines (Bates, 2015; “STEM in schools,” 2017). Harmon (1969) quantified this dynamic nature of academic disciplines identifying a lifecycle in which: 41% of their lifespan is emergence, 33% is unified growth and 26% differentiation into specialisations.

Biglan’s taxonomy (1973a, 1973b) classifies academic disciplines according to multi-dimensional characteristics identified by ‘bipolar adjectives’ (Biglan, 1973b, p.196) . These characteristics identify the level to which a discipline has:

‘(a) concern with a single paradigm (hard vs. soft), (b) concern with application (pure vs. applied), and (c) concern with life systems (life-system vs. non-life system)’

(Biglan, 1973a, p.204)

Becher & Trowler (2001, p.36) further characterise Biglan’s first two dimensions into: hard-pure, soft-pure, hard-applied and soft-applied; associating these directly with categories of academic disciplines and the nature of their pursuit of knowledge (

Figure 1-2).

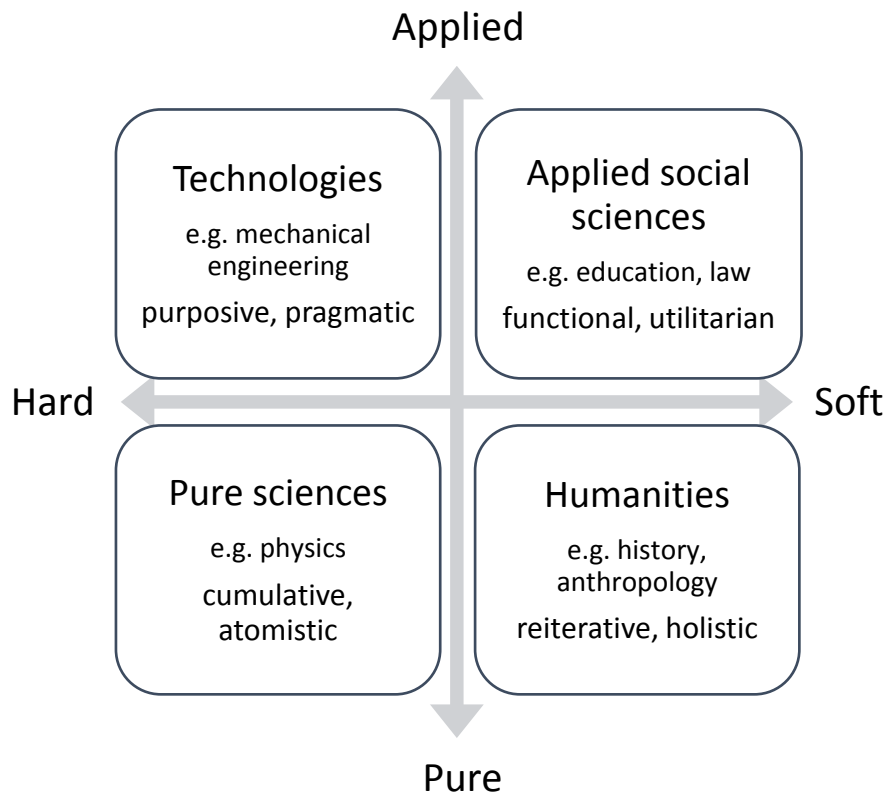


Figure 1-2: Characterisation of academic disciplines (after Becher & Trowler, 2001, p.36)

For applied disciplines, strong links to a recognised career path can emphasise their distinctive nature through a feedback mechanism between the institutional development of a curriculum and the professionalisation of the discipline. In these cases the disciplinary knowledge focusses on relevant skills for employment and fulfilment of the underlying social agenda and lies in the professional domain outside of institutional

education; while the coalescence of this knowledge into coherent theory, the methods and research to advance the knowledge and the curriculum developed to teach it, are internal to the academic domain of the educational institution. This feedback loop ensures that the discipline stays aligned to both the needs of the job market it feeds but also retains intellectual rigour (Figure 1-3) (Cohen & Lloyd, 2014; Eastwood, 1994; Krishnan, 2009). Åström (2008) identifies a variation to this loop where academics and professionals collaborate in research to build the knowledge base, often funded by the professional partners.

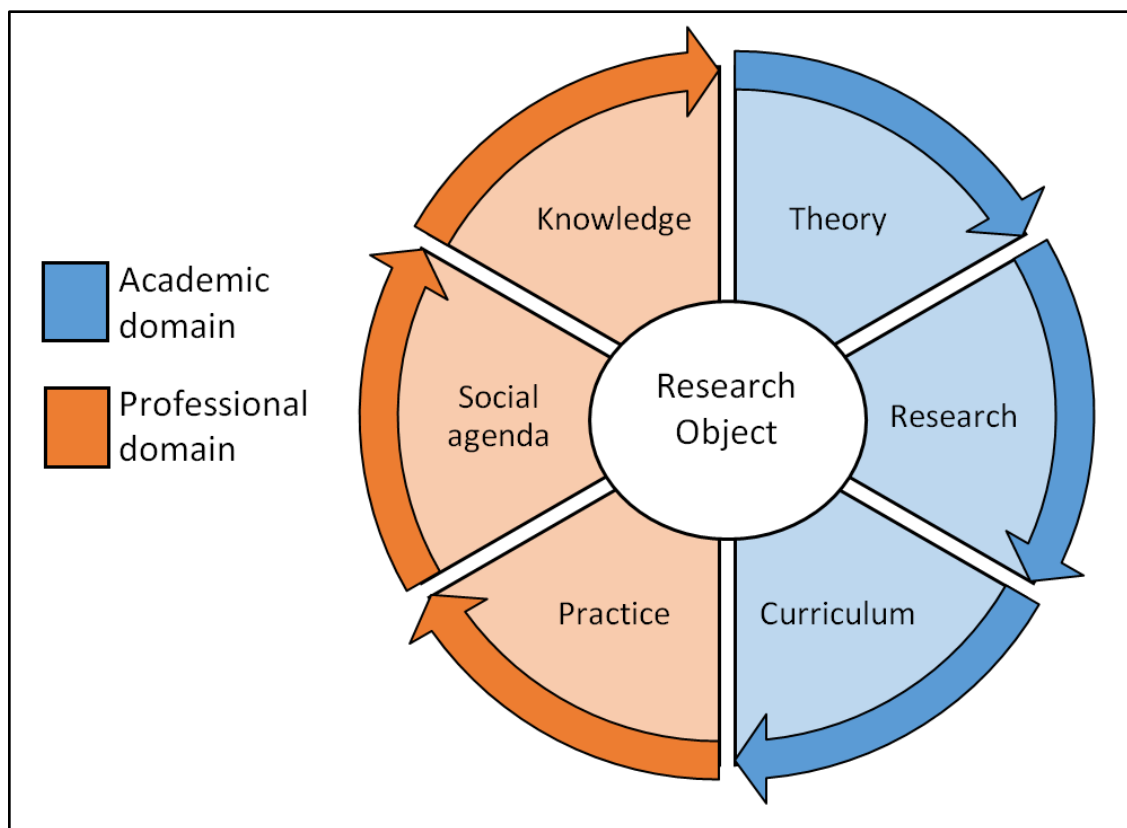


Figure 1-3: The academic to professional feedback loop of a professionally orientated discipline (after Cohen & Lloyd, 2014; Eastwood, 1994; Krishnan, 2009)

1.3 Information science as a discipline

Information science as a discipline is academically inter-disciplinary and multi-disciplinary (Capurro & Hjørland, 2003, p.364), and is a fusion of the professional practice (objective or disciplinary dimension) from which its knowledge base derives and the academic study of information as a research object (subjective or academic

dimension) (Bawden & Robinson, 2012; Harmon, 1971; Robinson & Karamuftuoglu, 2010; Smiraglia, 2014). Generally agreed to have its origins in the traditions of *bibliography*, the *documentation movement* and *library science*, the original focus was on the three main institutions created to store physical material – libraries, archives and the related museums (LAMs). The discipline revolved around the traditional problems of storage and retrieval (Bates, 2015) with sub-disciplines emerging from different sectors and subject areas as specialised responses to the problem when the quantity of materials stored became too great for the retrieval methods used (Harmon, 1971). This means that the boundaries of the discipline are fluid drawing upon disciplines across the arts and humanities, social sciences and natural sciences (Bates, 2015). The spectrum of information disciplines has been mapped by Bates (2015) according to their synergy with these academic fields and their focus on the cultural record or the sciences of information. Over fifty sub-disciplines, arising from eleven core disciplines, were identified.

Information science then can also be described as a meta-discipline, one that sits above and draws upon all other disciplines while researching specific problems in the information domain (Bates, 2015; Bawden & Robinson, 2012; Harmon, 1971; Zins, 2007). It:

‘deals with knowledge in all the conventional fields on the academic spectrum, but does so from a particular orientation or position that is needed to accomplish the work and the theorising of its area’.

(Bates, 2015)

As such information science’s research object can be identified as human recorded information and the complex issues surrounding it, across the different contexts of its creation and the subject matter it encompasses (Bawden & Robinson, 2012; Goonatilake, 1991; Robinson & Karamuftuoglu, 2010). However, defining the disciplinary boundaries of information science has proved to be an academic discourse in itself with different models developed to explain this.

Slamecka (1968) quoted by Harmon (1971, p.238) identified a systems based paradigm for information science: the *theory of information* considers the representation, measure and structure of information (academic dimension); the *theory of abstract information processes* considers activities of the information lifecycle (professional dimension); while the *theory of information systems* (technical dimension) embraces and builds upon the other two former theories (Figure 1-4).

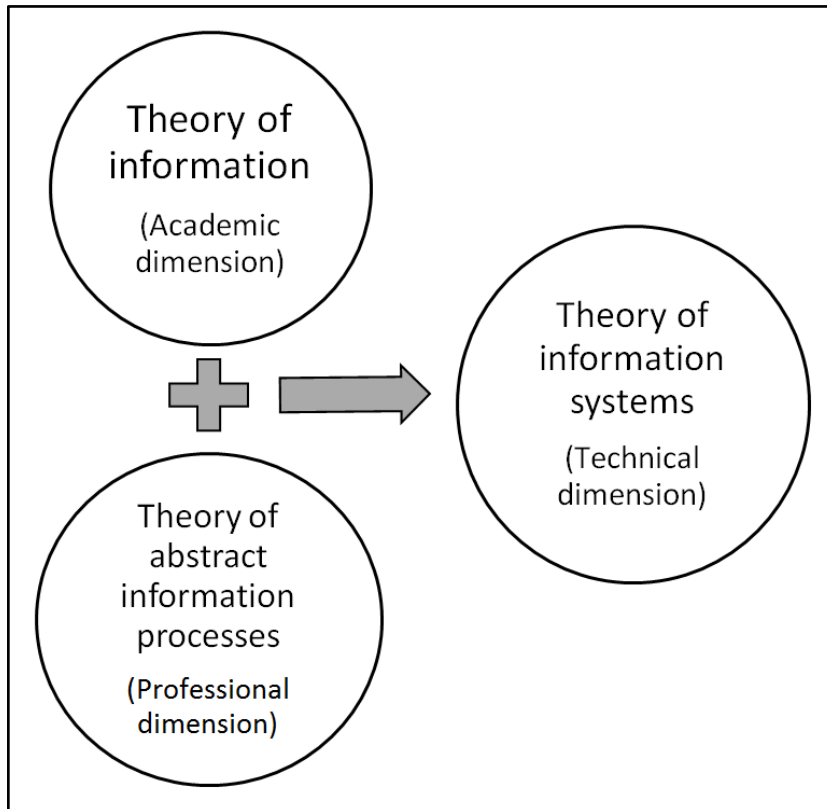


Figure 1-4: Slamecka's typology of information theories (1968)

Capurro & Hjørland (2003) note that the academic dimension of information science takes a top-down approach to the discipline; with the whole information domain as its primary research object and specific sub-disciplines the secondary research object. Conversely the professional dimension takes a bottom-up approach; with a narrow sub-discipline as their primary research object and the wider information domain its secondary focus (Figure 1-5).

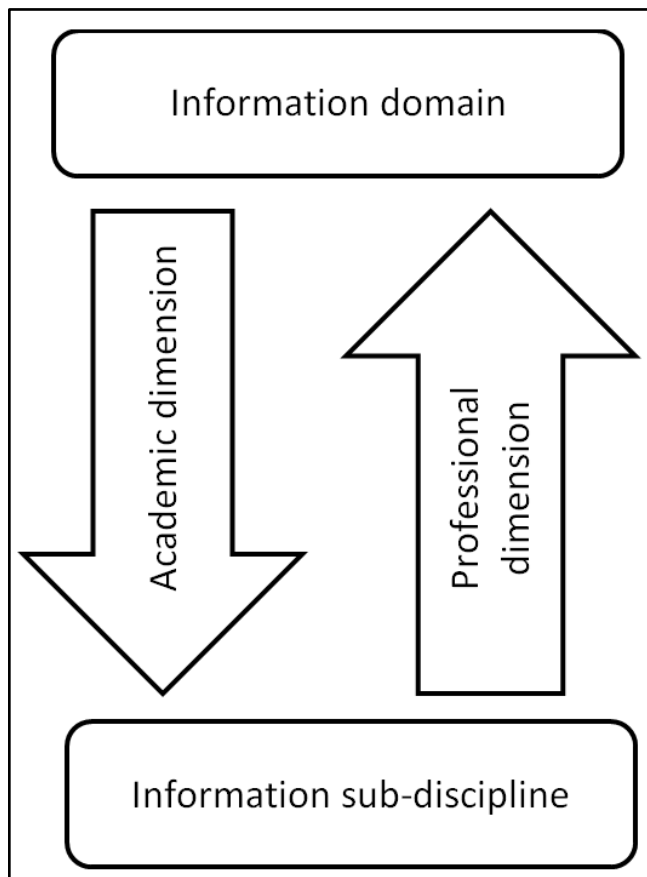


Figure 1-5: The academic and professional focus of information science (after Capurro & Hjørland 2003)

Zins (2007) identified multiple definitions of the information science discipline, which when analysed took either the academic dimension or the professional dimension as their research scope; with four phenomena of information as the research object – data (symbols that can be decoded), information (information management), knowledge (ideas and their communication) and message (selection and interpretation of information). Those identifying with the academic dimension had a generic research focus, while those identifying with the professional dimension had a narrow research focus on methods for mediating information. The technical dimension is encompassed by only two aspects of the professional dimension – one of which focuses on computer based technologies (Figure 1-6).

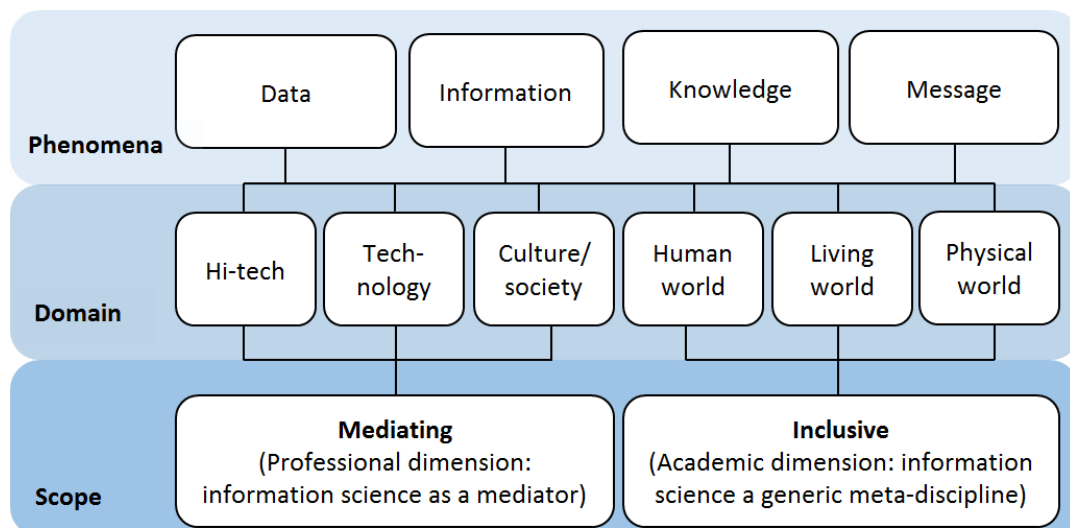


Figure 1-6: A conceptual framework for the information science domain (adapted from Zins, 2007)

Robinson & Karamuftuoglu (2010) identify six professional activities as the *information lifecycle* and the basis of the discipline (professional dimension). When combined with the information lifecycle identified by Capurro & Hjørland (2003, p.387) (quoting Borko (1968)) ten professional activities can be identified. Academic activity and by extension sub-disciplines build on top of these by combining components of the information lifecycle with the research approaches identified through domain analysis by Hjørland (2002) and the general context of the research (academic dimensions) (Figure 1-7).

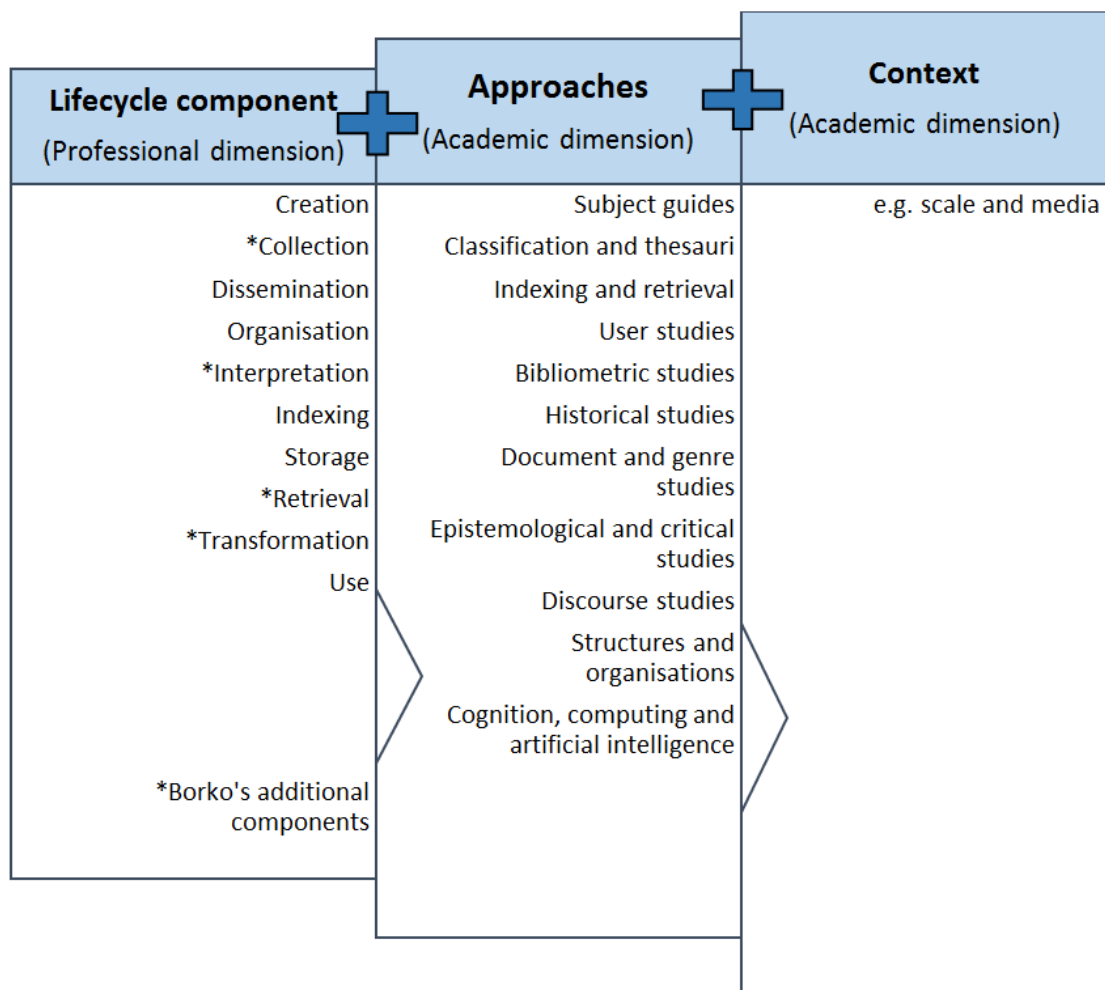


Figure 1-7: Robinson and Karamuftuoglu's model for information science (2010) with lifecycle components from Borko (1968)

Bates (2015) does not separate the academic and professional dimensions of the discipline. Rather she identifies seven generic facets (one of which embraces the technology dimension). Two or more of these facets can be combined to explain the academic dimension of different sub-disciplines of information science (Figure 1-8).

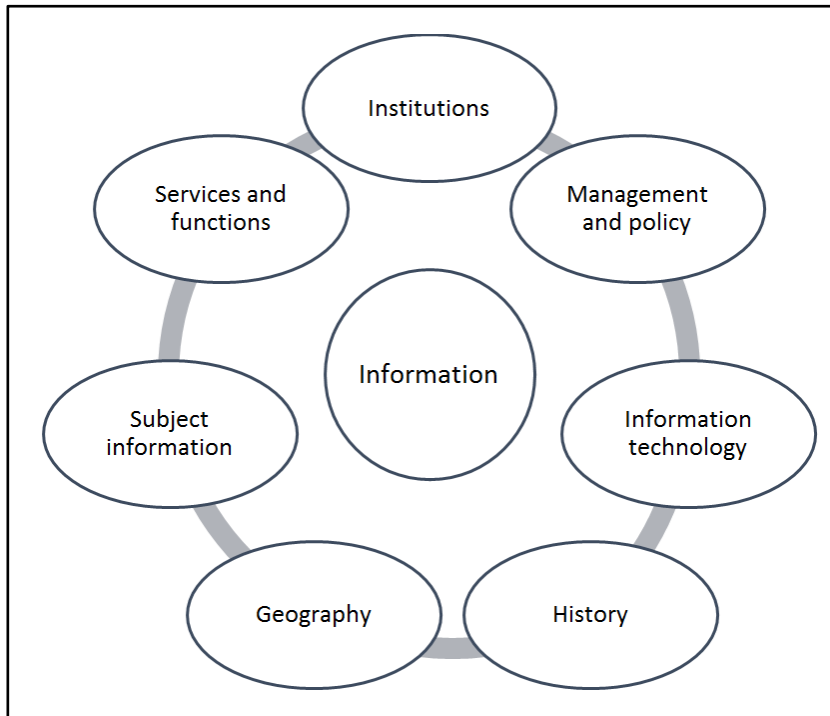


Figure 1-8: The generic facets of information science sub-disciplines (after Bates, 2015)

1.4 Curation in information science

Curation has not been a term generally used in information science, outside of the museum studies discipline, and is not specifically identified as a professional activity by the commentators discussed in Section 1.3, although it could be argued that Borko (1968) and Robinson and Karamuftuoglu's (2010) lifecycle components together constitute information curation. Certainly a similar set of duties for the *curation* of library resources have been identified (Daigle, 2012; Johnston, 2014; LibSource, 2017; Parsons, 2010; Valenza, Boyer, & Curtis, 2014). However they argue that *curation* goes beyond the mechanical activities of collecting materials and making them accessible, to the conscious design and development of a collection to support learning in a defined community while engendering trust and authority. This trust arises from human

judgement regarding value (Johnston, 2014) guided by policies (Daigle, 2012). LibSource, a US information consultancy, identifies this judgement of value as a professional role:

‘Curation is the act of individuals chartered with the responsibility to find, contextualize, and organize information, providing a reliable context and architecture for the content they discover and organize.’

(LibSource, 2017)

It is this combination of professionalism, policy and trust that has made *digital curation* the favoured term for activities that address the technical challenges, organisational tasks and resource implication of managing digital materials (Kenney, McGovern, Entlich, Kehoe, & Buckley, 2007), including the preservation of the core characteristics of a record which can be easily manipulated or compromised in digital materials; authenticity, reliability, integrity and usability (International Organization for Standardization, 2001, p.7). Digital curation is acknowledged as being a ‘more complex and dynamic undertakings than preservation alone’ (Tibbo, 2012, p.2) involving ‘the wider remit of maintaining persistence and access’ to all types of data (Higgins, 2011, p.80) and requiring ‘a wide array of individuals with various skills, knowledge and perspectives’ (Tibbo, 2012, p.3).

‘Digital curation, broadly interpreted, is about maintaining and adding value to a trusted body of digital information for both current and future use: in other words, it is the active management and appraisal of digital information over its entire life cycle.’

(Pennock, 2007)

1.5 Digital information – the new paradigm

A shift from the systems driven paradigm of *bibliography* and *documentation* began in the late 1960s with the early introduction of computer technology to their automation; and their subsequent side-lining into sub-disciplines such as library automation and (electronic) information retrieval (Bates, 2015; Hjørland, 2014; McCallum, 2003). Meanwhile the focus of research moved to the wider ‘sociological and epistemological’ (Capurro & Hjørland, 2003, p. 389) or cognitive approach, greatly increasing the scope of information science as a discipline (Capurro & Hjørland, 2003; Ellis, 1992; Harmon, 1971; Hjørland, 2014).

Looking back at Zins’ model (Zins, 2007) and mapping it to explicit facets of digital curation, the discipline could be said to be a sub-discipline of information science restricted to mediating data and information in a hi-tech domain (Figure 1-9).

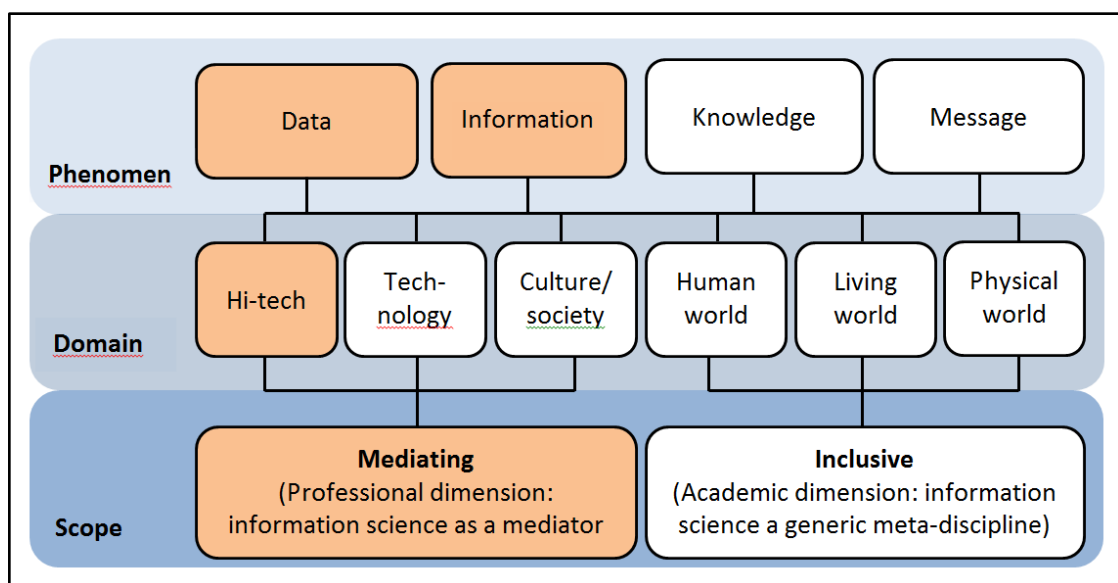


Figure 1-9: Zins’ model applied to digital curation (after Zins, 2007)

Similarly mapping Bates' 2015 facets to those that could be explicitly cross-walked to the primary foci of digital curation restricts the discipline's reach Figure 1-10.

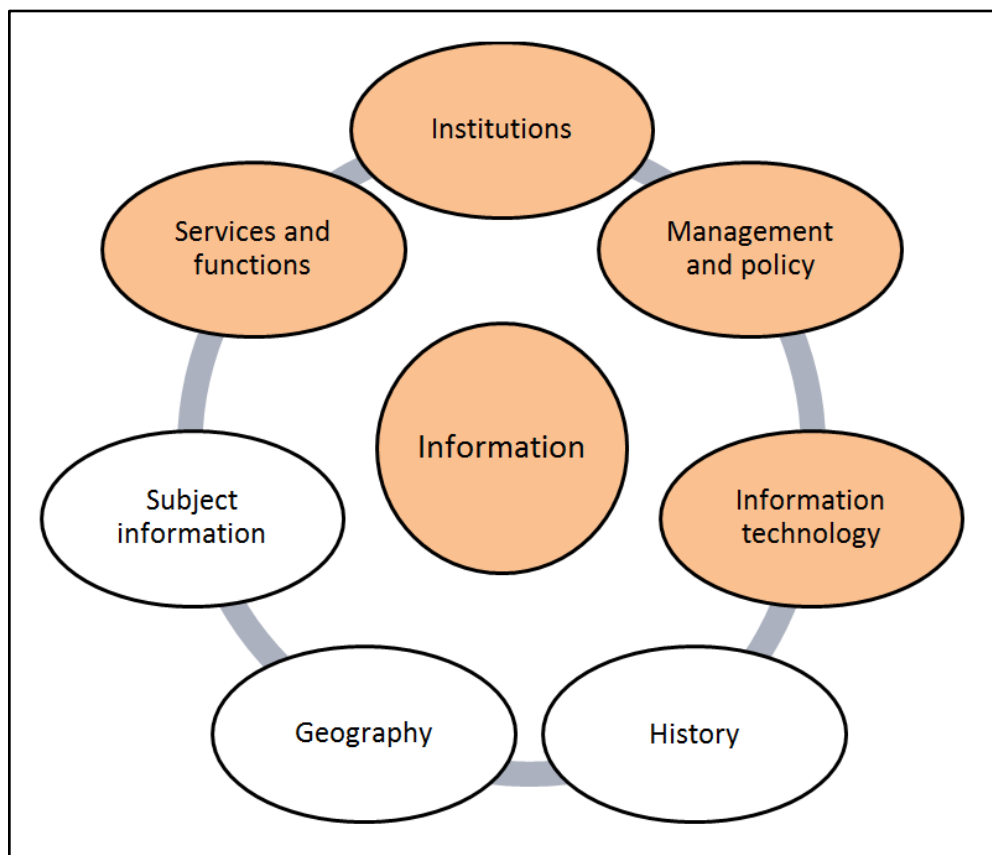


Figure 1-10: Bates' model mapped to digital curation (Bates, 2015)

Harmon (1971) predicted a 'complete supra-system of knowledge which would unify the arts, sciences and professions' (p.240). It is the author's contention that this prediction has become a reality, and with it a third paradigm in information science. The advents of the personal computer and the Internet have changed the information ecology so that not only their metadata but also the actual information being managed is manifested digitally (Hjørland, 2014). Of the 54 sub-disciplines of information science identified by Bates (2015) a third pertain exclusively to some specialist aspect of the management of digital materials e.g. digital humanities, digital asset management, digital libraries, data mining; and a number of domain specific branches of informatics. This has led to new ways of conceptualising information as a research object and changed the information professional from a gatekeeper to an enabler (Floridi, 2010).

Digital curation, the subject of this study, focuses on the holistic inter-play of the professional, academic and technical dimensions to ensure that information *created digitally* remains accessible and usable over the long-term. As a discipline it has many synergies with computer science although this traditionally focuses more narrowly on the digital technology used to create information, than the information itself. Digital curation's research focus on the digital manifestation of information, coupled with the normalisation of creating and distributing information in the digital realm, means it has reach into all the information science disciplines and sub-disciplines whether they are explicitly concerned with digital information (such as digital libraries, digital asset management and informatics); or whether their concern is format neutral (such as specialist libraries and records management). However, digital curation is not included as a sub-discipline of information science in Bates' 2015 typology. Those represented in this could be further classified into concern with:

- Information's support for societal function;
- The subject matter of the information;
- Information systems design; and
- Storage location of the information.

Digital curation, being uniquely concerned with the manifestation of the information cannot be included in any of these classifications, and as such has no clear disciplinary boundaries. This being the case it is the author's contention that it should be characterised as a sub-meta-discipline – one that is within the information science meta-discipline but transcends and influences all of its disciplines and sub-disciplines (Figure 1-11).

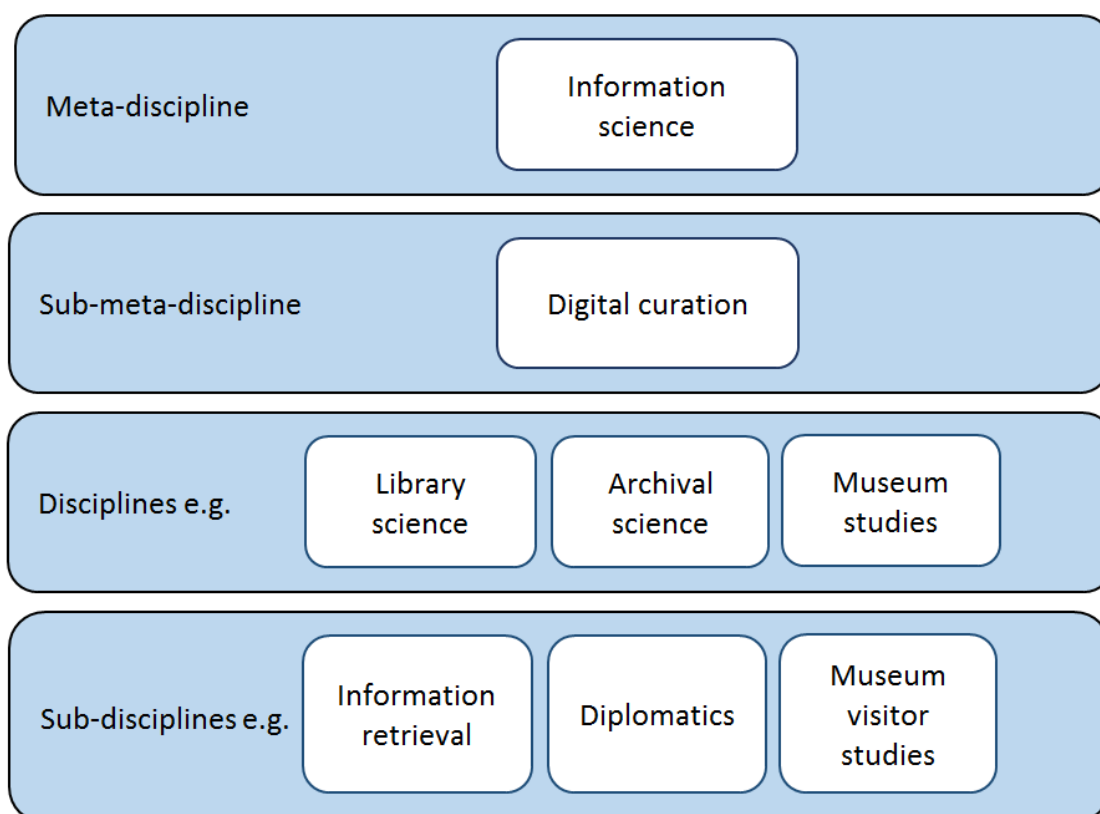


Figure 1-11: Digital curation as a sub-meta-discipline of information science

The realisation that the digital manifestation of information represented a new paradigm, and so required specialist curation methods, was slow to emerge, so that a chaotic situation developed. Digital material was being created, but because of ignorance and poor standards of care was being lost through technical obsolescence or neglect. It was 30 years after digital technologies were first employed by the discipline that the chaotic situation was articulated, and the consequent loss of information highlighted as a problem for information science (Hedstrom, 1998; Ross, 2000) and the aforementioned professional bodies were established.

Less than twenty years later digital curation is a clearly defined subject internationally, and the focus of specialist professional organisations and research groups. It has become an academic discipline, with master's level courses offered by universities worldwide (DigCurve, n.d.; Digital Curation Centre, n.d.).

1.6 Positioning the research

The key aim of the author's research has been the identification, articulation and elaboration of the theories and concepts that characterise digital curation towards its recognition as a distinct discipline, concerned with managing the new digital paradigm, within the information science domain.

Her research has engendered the *academic dimension* of digital curation and facilitated developments in the *professional dimension* so that it:

1. Enables an understanding of the societal and cultural space inhabited by digital curation through identification of its origins and drawing its boundaries as a professionally orientated meta-discipline within information science (see papers 1 and 2).
2. Encodes and communicates the chief ideas and concepts that underpin the discipline through the development, elaboration and testing of a model that conceptualises the discipline's underlying theories and vocabularies (papers 3-8).
3. Facilitates credence for the discipline in the Higher Education sector as it advances and implements academic curricula (paper 9).
4. Evaluates the applicability of the core theories of the archives science discipline within the new digital paradigm of information science (paper 10).

The audience for this research has been drawn from both the academic and professional domains across the sub-disciplines of information science and to a lesser extent the related discipline of computer science. Several of the works, particularly the conceptual model (Paper 5), are widely cited in academic papers and used in the professional sphere to educate about the discipline and plan and structure practical implementations.

1.7 Limitations of the work

Digital curation, ‘blends both technical (digital) and conceptual (curation) facets’ (Tibbo, 2012, p. 4). This work is not concerned with the development of tools, standards and technologies that support the *technical dimension* of digital curation nor with its synergies with the computer science discipline; rather these are highlighted when they play a defined role in the conceptual development of the discipline.

The author of this work was employed as Standards Adviser at the Digital Curation Centre at the University of Edinburgh from May 2006 to April 2010 and thereafter as Information Studies Lecturer at Aberystwyth University. As this work indicates the original contribution the author has made to the progressive identification of digital curation as a new discipline, the work will by necessity elaborate this through the lens of the aims, objectives and contractual requirements of these employing organisations.

1.8 A note about definitions

Despite a constantly developing understanding of digital curation as a holistic challenge, and the continuous maturing of the discipline, the terms *digital preservation* and *digital curation* are still used interchangeably in many activities, reports and research publications. In this work the broader definition *digital curation* will be used except where discussing a technical subset of the discipline or quoting works using the term *digital preservation* (see *Definitions* p.xi).

2. Contributions to knowledge

The author identified that a gap in the codification of the theories and concepts of digital curation was hindering the development of a cohesive cultural identity with clear disciplinary boundaries amongst professionals. Her overarching research hypothesis has been that a clear and systematic exposition of digital curation's conceptual space would be the necessary catalyst to a definition of discipline.

The author's contributions to new knowledge lie in the crystallisation of the theories and concepts of digital curation towards its development as a coherent discipline within both the professional and academic dimensions of information science.

A summary of the main contributions and conclusions from the research are highlighted in Sections 2.1 and 2.2 below while specific details of these contributions will be discussed on a paper by paper basis in Chapter 3 and discussed in more depth, along with parallel contributions related to the professional dimension in Chapter 4. For ease of reference the published works have been numbered 1 to 10 and a summary list can be found in Appendix A. Meanwhile the full-text of the pre-prints of each of these works is in Appendix B. Declarations signed by co-authors concerning relative contributions to papers are in Appendix C.

2.1 Main contributions

The author claims original contributions to knowledge in eight key areas:

1. The examination and analysis of the professional and organisational processes that supported digital curation's emergence as an academic discipline (Paper 1);
2. Characterisation of the professional function of digital curation in relation to libraries, archives and museums, the traditional dominant sub-disciplines of information science (Paper 2);
3. Evaluation of the applicability of current archival theory to the digital paradigm (Paper 3);

4. Development of a conceptual model to both underpin digital curation as an academic discipline and to inform professional implementation (Papers 4 and 5);
5. Empirical evidence of the applicability of the conceptual model to curating research datasets in the professional dimension (Paper 6);
6. Application of the conceptual model to an advisory framework for professional implementations (Paper 7);
7. Specific best practice guidelines for curating data in a custodial context (Papers 8 and 9);
8. Analysis of digital curation curriculum competency requirements and subsequent development of academic curricula (Paper 10).

2.2 Research conclusions

The research conclusions drawn from the author's original contributions are as follows:

1. Iterative professional processes supported by systematic funding initiatives enabled the disciplinary space occupied by digital curation to be identified, explored and developed (Paper 1);
2. This disciplinary space transcends the traditional boundaries of the information science disciplines libraries, archives and museums, due to the unique curation needs of information manifested digitally (Paper 2);
3. The digital paradigm disrupts the accepted theoretical principles underpinning professional practices in archival science (Paper 3);
4. Conceptual modelling in digital curation builds a delineated theory that can drive an academic professional feedback loop (Figure 1-3) (Papers 4-9);
5. A conceptual model that accommodates the application of digital curation theory in multiple contexts capacitates professional practice and knowledge development (Papers 4-9);
6. Higher education in digital curation can be delivered as part of the curriculum for traditional information science disciplines but its status as a sub-meta-discipline means that dedicated curricula may be more applicable (Paper 10);

7. Higher education in digital curation requires both theoretical and experiential knowledge (Paper 10).

2.3 Representative contributions and conclusions

The original academic contributions to the development of digital curation as a discipline, and the conclusions made by the author, are summarised above and detailed in the ten published works appended.

- Papers 1 to 3 consider the essence of digital curation as a discipline and what makes it distinctive enough to require its own theoretical basis. Paper 1 examines how it emerged as a new discipline from chaotic first beginnings; while Paper 2 identifies digital curation as a *change agent* eroding traditional disciplinary boundaries. Paper 3 focuses on archival science as an established discipline and critiques the impact of the digital paradigm and specific digital curation methods on the robustness of its core academic theories.
- Together papers 4 and 5 cover the development of a conceptual model as a theoretical underpinning for the discipline. The former presents preliminary results from desk research and focus groups internal to the DCC; the latter presents the refined model following input from external disciplinary specialists.
- Papers 6 and 7 present work testing and applying the conceptual model. Paper 5 exemplifies its use as a tool to empirically analyse research data management practices. Paper 6 applies the model to the classification and presentation of standards to support digital curation in an advisory tool.
- Papers 8 and 9 elaborate the professional dimension of digital curation: the former uses the conceptual model to contextualise holistic advice, the latter concentrates on more detailed information on implementing certain components of the model.
- Paper 10 examines curriculum requirements for digital curation from the perspective of the archival science discipline.

3. Details on contributions to knowledge

Each paper in this submission has made a contribution to knowledge by helping the definition of digital curation, a defined meta-sub-discipline of information science, to progress (Figure 1-1); and thus provision and support for its training and education. Contributions span both the professional and academic dimensions, demonstrating the academic to professional feedback loop in practice (Figure 1-3). The key contributions made by each of the papers will be explored below while their wider context will be discussed in Chapter 4. Table 3-1 summarises the contributions of the 10 papers to the academic and professional dimensions of digital curation.

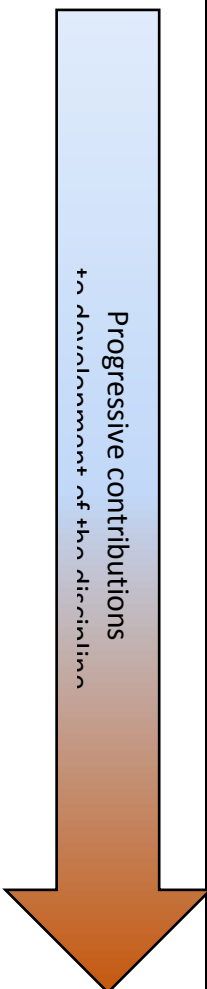
|  | Paper Number | Developmental stage number (Figure 1-1) | Academic Dimension | Professional Dimension |
|--|--------------|---|--|---|
| | 1 | 1 and 2 | Historical analysis of discipline | Understanding of disciplinary origins |
| | 2 | 1 - 3 | Disciplinary conceptual space analysis | Understanding of disciplinary context and relationships |
| | 3 | 1 -3 | Sub-disciplinary conceptual space analysis | Re-evaluation of accepted theories and methods |
| | 4 and 5 | 3 and 4 | Models and organises disciplinary conceptual space | Enables practical implementation to progress |
| | 6 and 7 | 5 and 6 | Tests and applies conceptual model | Provision of a tested research tool |
| | 8 and 9 | 6 | Elaborates conceptual model | Best practice guidance |
| | 10 | 7 | Identifies educational requirements | Enables course development |

Table 3-1: Contributions to digital curation's disciplinary development by the papers submitted

3.1 Paper 1: *Digital Curation: The emergence of a new discipline* (2011)

Paper 1's contribution lies in the academic analysis of the historical origins of digital curation's professional dimension to enable this to be understood by both current and future practitioners and academic researchers. History illuminates the present by examining the past (Glassie, 1994), and its purpose is encapsulated in a quotation attributed to the author James Baldwin 'know from whence you came. If you know whence you came, there are absolutely no limitations to where you can go'.

Taking a UK focus the paper identifies the progressive development of digital curation as a discipline through: early exemplar projects in the arena, the origins and progress of a funded agenda for digital curation, the establishment of support organisations beyond the UK, and the first curricula development projects.

Originally commissioned by the editors of *ARC* – the magazine of the *Archives and Records Association UK and Ireland* (ARA),⁴ to provide context to changing curricula in archives management education, the depth and length of the resulting paper, as well as the conclusions made, meant it was more suitable for a specialist peer reviewed journal.

3.2 Paper 2: *Digital curation: The challenge driving convergence across memory institutions* (2013)

Paper 2's specific contribution lies in the analysis of digital curation's disciplinary space in relation to LAMs. Digital curation is not only identified as a meta-discipline but also as a *change agent* that enforces convergence across these sub-disciplines. The paper characterises the stages in a continuum of collaborative working, analyses the primary ethical differences that hinder this, and categorises the benefits, risks and success measures of doing so.

⁴ Archives and Records Association UK and Ireland (ARA): <http://www.archives.org.uk/>

This peer-reviewed paper contributed directly to the initiation of UNESCO's *Persist Programme* which 'aims to create a platform to support the dialogue among these parties [governments, memory institutions and the ICT industry] in order to enhance the continuity of content' (UNESCOPersist, 2017). It was presented at the *Memory of the World in the Digital Age: Digitization and Preservation Conference* (2012) as part of a panel entitled *Convergence of Challenges, Institutions and Knowledge for Digital Curation*.⁵ UNESCO's conference gathered together 500 members of the international digital curation community to: share current practices, and prepare the *Vancouver Declaration* – an international agreement on future action (United Nations Educational Scientific and Cultural Organization & University of British Columbia, 2012). These activities informed the instigation of *Persist* to take the declaration forward.

3.3 Paper 3: *Archives context and discovery: rethinking arrangement and description for the digital age* (2014)

Paper 3 focuses on digital curation practice within one sub-discipline of information science – archival science. It contributes a critique of the accepted theoretical principles in the discipline and their intersection with digital curation. The paper examines one digital curation activity – metadata – and its role in management, discovery and access to digital objects through two case studies. The applicability of current pervasive metadata standards, which arise from and adhere to theoretical principles regarding contextual maintenance, is examined. Like Paper 2, Paper 3 demonstrates the new paradigm heralded by digital information and its role as a *change agent* in accepted disciplinary practices.

Co-authored by colleagues from the Wellcome Library and the National Library of Wales, who provided the case studies, this peer-reviewed paper was delivered at the International Council on Archives Conference in 2014⁶ where it contributed to an expert

⁵ Memory of the World in the Digital Age: Digitization and Preservation Conference, 2012: <http://www.unesco.org/new/en/communication-and-information/events/calendar-of-events/events-websites/the-memory-of-the-world-in-the-digital-age-digitization-and-preservation/>

⁶ International Council on Archives Conference, 2014: <http://www.ica.org/en/annual-conference-2014>

session and the wider debate regarding the description of archives. Although addressing fundamental activities of digital curation, the language used in the paper is specific to audience drawn exclusively from the archives sub-discipline.

3.4 Paper 4: *Draft DCC Curation Lifecycle Model (2007)*

Paper 4 is the first public draft, for international professional comment, of a generic high-level conceptual model of the stages involved in curating digital material across its lifecycle. Published in the premier peer-reviewed disciplinary journal, *The International Journal of Digital Curation*,⁷ it contributes the beginnings of a theoretical systemisation of the activities and workflow that comprise digital curation in an easily understood graphical format with accompanying definitions to inform practice in the professional dimension.

The model arose out of professional need from the DCC, as a training and advice provider, for a simple method to systematically:

- Explain the functions and activities of digital curation;
- The underpinning policies and processes required; and
- To identify and classify standards and technologies for successful implementation.

The draft was developed through desk research and staff focus groups and was informed by the author's ongoing professional roles with standards bodies (see Section 4.2).

3.5 Paper 5: *The DCC Curation Lifecycle Model (2008)*

⁷ International Journal of Digital Curation: <http://www.ijdc.net/>

Paper 5 has been very influential in defining the discipline of digital curation and continues to make a significant contribution to both its academic and the professional dimension.

‘Digital Curation tracks the life cycle of a digital object.... This is perhaps most famously captured by the Digital Curation Centre’s digital curation graphic that has been extensively repurposed and reused.’

(Daigle, 2012, p.95 & p.105)

Like the preceding draft (Paper 4) Paper 5 was published in *The International Journal of Digital Curation*. It incorporates international comments received on the draft to provide a consensual theoretical model and syntactical definition of the activities needed to curate digital materials over their lifecycle. The DCC Curation Lifecycle Model (DCC:CLM) identifies and organises the conceptual space occupied by digital curation and defines the language to describe it, so that the focus of activity can progress along the developmental continuum from Stage 3 to solving the concrete problem through to Stage 5, advancement and implementation of research methods (Figure 1-1). Its clear exposition delivers a simple theoretical tool which facilitates development for both academics and professionals working in all aspects of the discipline.

‘...the DCC’s Curation Lifecycle Model, an excellent piece of information visualisation that sums up much of what one should bear in mind when considering all matters relating to RDM [research data management].’

(Stewart, 2012)

Quickly adopted by the professional community it has formed the foundations of digital curation activities in both the academic dimension e.g. curriculum development, educational courses and text books and professional dimension e.g. design and development of tools, digital curation needs analysis, and implementation of digital curation projects. A taste of the wide scope of the use, repurpose and reuse of the DCC:CLM can be found by undertaking a simple Google image search.

3.6 Paper 6: *Curated databases in the life sciences: The Edinburgh Mouse Atlas Project (2009)*

Paper 6's contribution is its successful proof-of-concept demonstrating the disciplinary development of digital curation: the theoretical model (Papers 4 and 5), developed in the academic dimension, can be successfully applied as a research tool to the analysis of existing digital curation practices and lead to recommendations for improved professional methods, adding to the discipline's body of knowledge (Figure 1-1, Figure 1-3).

The *Edinburgh Mouse Atlas Project* (EMAP),⁸ which 'uses embryological mouse models to provide a digital atlas of mouse development' (EMAP, n.d.), is used as a case study to bench-mark existing digital curatorial practices against the conceptual ideal.

The first co-authored paper presented in this work, it provides empirical evidence of the applicability of the conceptual model to the professional curation of life sciences research datasets. The author's contribution to the report was chiefly in Sections 4 and 5: identifying the curatorial practices undertaken, analysis of these against the DCC:CLM, and making recommendations for future practice. This report formed one output from the JISC funded *SCARP Project* (2007-2009), which studied differences in data curation practices across seven disciplines, and recommended improvements, successfully using the DCC:CLM as an analytical tool (Digital Curation Centre, 2010).

'The resulting case studies, each with recommendations and findings for the research groups and for the range of stakeholders in digital curation, demonstrated that curation tools, such as the Digital Curation Lifecycle Model, were useful provided effort was applied to adapt them to the context of 'live' data creation and curation.'

(Key Perspectives Ltd, 2010)

⁸ Edinburgh Mouse Atlas Project (EMAP): <https://www.emouseatlas.org/emap/home.html>

3.7 Paper 7: *DCC DIFFUSE standards frameworks. A standards path through the curation lifecycle* (2009)

Paper 6 demonstrated that the DCC:CLM (Papers 4 and 5) can successfully be applied as a tool to the practical analysis of curation methods. Paper 7's contribution lies in the demonstration of this theoretical model's application to the organisation of services to support digital curation professionals. This paper reports on the *DCC Diffuse Standards Frameworks Project* which the author developed over 3 years as an advisory tool for those trying to identify appropriate standards and technologies to implement (Digital Curation Centre, 2009).⁹ It used the model to contextualise professional and technical standards in a continuously updated tools registry according to the curation action they supported, using the DCC:CLM graphic as the first point of entry for searches. Online searchable domain specific frameworks were developed in conjunction with domain specialists. Additional context and description was provided through links to *Wikipedia* entries and crowd-sourcing techniques to keep these up to date encouraged.

Although still available online this tool has not been updated or extended since the author left the DCC due to a change in funding and staffing. However the concept has been reused: DCC:CLM actions are used to classify tools and information for searching, browsing and discovery by both the *Community Owned Digital Preservation Tool Registry* (COPTR) in their *POWRR Tool Grid*,¹⁰ and the DPC in their *Preservation Lifecycle Knowledge Base* (Digital Preservation Coalition, 2017).¹¹

3.8 Paper 8: *The lifecycle of data management* (2012)

⁹ DCC Diffuse Standards Frameworks Project: <http://www.dcc.ac.uk/resources/standards/diffuse>

¹⁰ *Community Owned Digital Preservation Tool Registry POWRR Tool Grid*:
<http://www.digipres.org/tools/>

¹¹ Digital Preservation Coalition *Preservation Lifecycle Knowledge Base*:
<http://www.dpconline.org/knowledge-base/tags/17-preservation-lifecycle>

Paper 8's contribution lies in the elaboration of the theoretical foundation for digital curation articulated in the DCC:CLM into professional guidelines for best practice. Paper 8 substantiates the DCC:CLM's definitions of the lifecycle actions giving concrete advice on how to implement them practically including the supporting policy environment required and technical standards to adopt.

Further contribution comes from being included as a foundational chapter in a book that filled an acknowledged gap in the literature surrounding the developing methodologies for research data management (Chow, 2014; Stewart, 2012). Paper 8 constituted *Chapter 2* of the book *Managing research data* (Pryor, 2012) which collected and consolidated achievements from the DCC's second round of research funding shortly after data curation was being mandated by funding councils through alignment with the RCUK common principles on data policy (Digital Curation Centre, 2017; EPSRC, 2011; Research Councils UK, 2015) .

The book as a whole was well received by the professional information science community, with favourable reviews in disciplinary journals, while spending several weeks at number one in Amazon's *Library and Information Sciences* category, a slot it reached five days after publication. Paper 8 was highlighted in a review by Sally Rumsey of the Bodleian Library in the journal *Ariadne*:

'Sarah Higgins describes the data management lifecycle, as conceptualised by the DCC. The discussion of the separate stages of the lifecycle could each stand perfectly well as independent briefings for those wanting a short overview.'

(Rumsey, 2012)

3.9 Paper 9: *Data modelling for analysis, discovery and retrieval* (2016)

Paper 9's contribution is the further substantiation and reinforcement of best practice in the professional dimension for two curation actions described in the theoretical

DCC:CLM – *Create or Receive* and *Description and Representation Information*. Building on Paper 8 the work brings together accepted curation methods for these two actions into a detailed information set on practical professional implementation (though not explicitly referencing Paper 8 or the DCC:CLM). It focusses firstly on ensuring that a digital information object is fit for purpose through identifying methods for modelling its creation in terms of user need and interoperability with other technical infrastructures; and in terms of ease of curation for longevity. Secondly the work focuses on best practice for ensuring discoverability and retrieval by users through metadata modelling.

Paper 9's further contribution comes from its role in the book *Managing digital cultural objects; analysis, discovery and retrieval* (Foster & Rafferty, 2016). Designated *Chapter 2*, it underpins the academic contextual analysis that precedes the chapter and professional case studies that follow by explaining 'data modeling [sic] as a foundational process for all subsequent choices made in the creation of a digital collection' (Frazier, 2017).

Paper 9 was commissioned by the editors of the book which was designed to fill the 'gap in the field of information studies for theoretical scholarship that focuses on the challenges and problems of interpretation of non-textual information' (Foster & Rafferty, 2016, p. xviii). Like *Managing research data* this book, as a whole, gained positive reviews in the disciplinary journals and was noted for its timely publication (Ballan, 2017; Bartlett, 2016; Brown, 2017; Eden, 2017). *Chapter 2* (Paper 9) was noted by one reviewer as 'a thoughtful and thorough introduction which highlights the importance of basing data-modelling decisions on a thorough understanding of the needs of users' (Brown, 2017, p.150).

3.10 Paper 10: *Mainstreaming Digital Curation: An overview of activity in the UK archives and records management profession* (2013)

Paper 10's contribution lies in its synthesis of a five level competency framework for higher education in digital curation, within the archives and records discipline, which addresses both theoretical and technical training. The paper presents two case studies of existing provision and compares these to the emerging professional competency statements for archives professionals, and existing professional knowledge, to arrive at the new framework.

This peer reviewed paper contributed to both specific digital curation curricula developments at Aberystwyth University and international discussion on such curricula. It was delivered at the *Framing the Digital Curation Curriculum Conference* (2013)¹² which brought together educators from across the world as part of the European Funded *Digital Curator Vocational Education Europe Project* (DigCurV).¹³ Instigated and co-authored by a colleague at University College London (UCL), the paper arose out of, and consequently fed back into, professional duties being undertaken by the author as a lecturer in Information Studies at Aberystwyth University and as a personal member of the ARA:

1. Developing and delivering cross-course post-graduate modules in digital information management for qualifying archivists and librarians;
2. Developing a stand-alone MSc in Digital Curation for professional accreditation;¹⁴ and
3. Exploring continuing professional development in digital curation for qualified archives professionals as Chair of the *ARA Section for Archives and Technology* (ARA SAT).¹⁵

¹² *Framing the Digital Curation Curriculum Conference* (2013):

<http://www.dpconline.org/news/digcurvconference>

¹³ *Digital Curator Vocational Education Europe Project* (DigCurV): <http://www.digcurv.gla.ac.uk/>

¹⁴ Aberystwyth University Information Studies: MSc in Digital Curation:

<https://courses.aber.ac.uk/postgraduate/digital-curation-masters/>

¹⁵ ARA Section for Archives and Technology: <http://www.archives.org.uk/about/sections-interest-groups/archives-a-technology.html>

4. Discussion on contributions to knowledge

Chapter 3 explored the key contributions made to knowledge in each of the papers presented. The concepts investigated and theoretical frameworks developed in the academic domain were underpinned by experience in the professional domain and further strengthened by their practical implementation.

The author's contributions to knowledge are not only made through the academic papers cited, but through the wider professional context in which they were written, and their impact on professional practice. This chapter will discuss the papers thematically in light of these. Figure 4-1 summarises the themes explored by the author's work and their key progressive contribution to the development of the discipline. Appendix D presents a chronological list of the author's relevant professional activities for each theme, while Appendix E presents a current *Curriculum Vitae*.

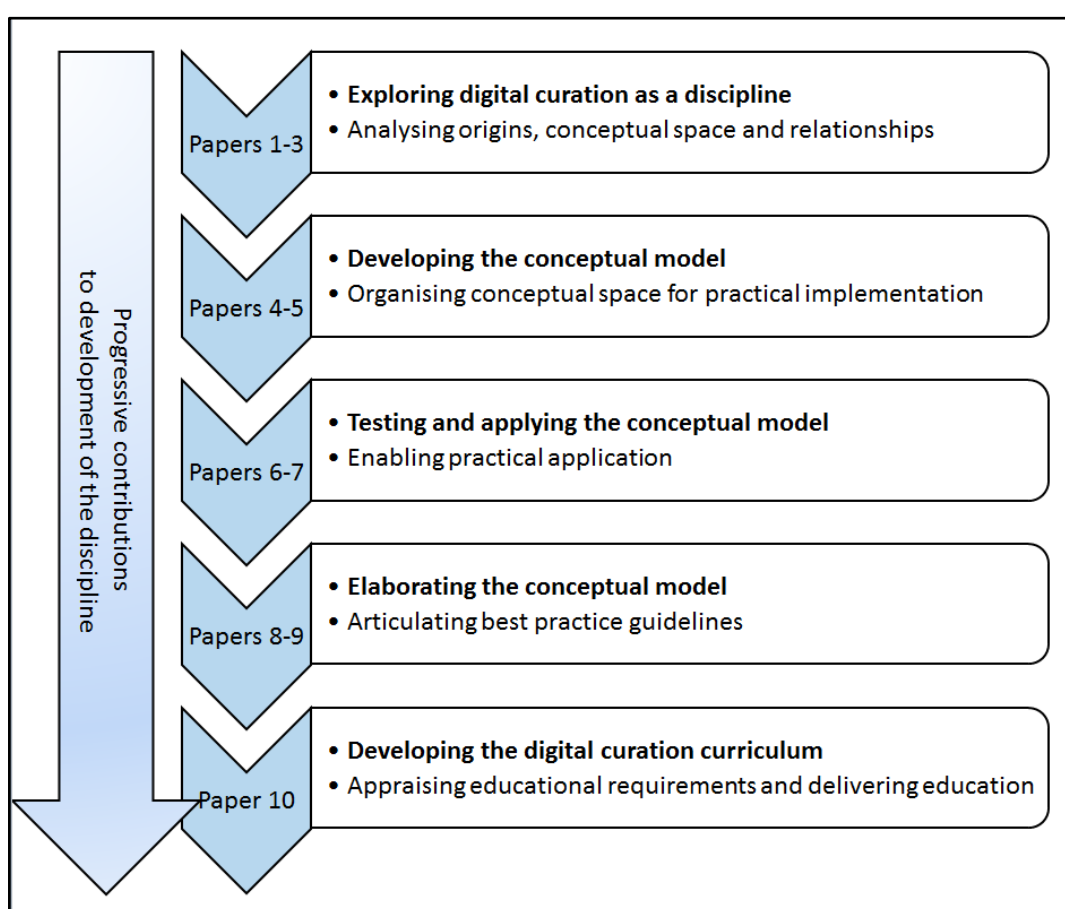


Figure 4-1: Author's themes explored and their contribution summarised

4.1 Papers 1-3: Exploring digital curation as a discipline

Digital curation arose from within the professional dimension of the information sciences disciplines while maintaining synergies with computer science. Its origins lie in two parallel early research foci: *preservation of electronic materials* - maintaining the bit-stream of those records and archives we would now call *born-digital* (Day, 1997; Hirtle, 2010, p.125; Marc Fresko Consultancy, 1996); and *digital preservation* - producing digital surrogates of analogue material through digitisation (Hirtle, 2010, pp. 124-125).

The more holistic term *digital curation* developed through increased understanding of the need to maintain access to digital material through equal attention to technical challenges, organisational tasks and resource implication (Kenney et al., 2007); while preserving its authenticity, reliability, integrity and usability (International Organization for Standardization, 2001, p.7). Digital curation is regarded as the 'active involvement of information professionals in the management, including the preservation, of digital data for future use.' (Yakel, 2007).

The term started to be used after the 2001 *Digital Curation: Digital Archives, Libraries and e-Science Seminar* that launched:

- The DPC,
- The UK e-science Programme, and
- The influential *Open Archival Information Reference Model* (OAIS) (Consultative Committee for Space Data Systems, 2002) (see Section 4.2) (Beagrie & Pothen, 2001; Kim, Warga, & Moen, 2013, p. 67; Lee & Tibbo, 2011, p. 126).

It moved into the mainstream with the publication of the *E-science curation report* (Lord & Macdonald, 2003) and the DCC's foundation in 2004.

The author joined the DCC's staff in 2006 shortly before the second funding stream had narrowed its focus to research data management, a sub-discipline of digital curation. A qualified and experienced professional technical archivist she had worked widely with

metadata across archive, library and museum technical systems and participated in Edinburgh University Library's *Digital Archives Research Project* (Semple, 2003).

Papers 1-3 have their roots in the advisory role assumed at the DCC, where the intersection between professional archival training and digital curation were confronted; while a deep knowledge of the origins and scope of the latter were acquired. The academic role at Aberystwyth University allowed these intersections and origins to be explored and articulated.

Paper 1 identifies the discipline's roots, always at the forefront of decisions made at the DCC, which was managed by disciplinary pioneers; while papers 2 and 3 explore the professional and academic disciplinary space occupied by digital curation in relation to information science where it holds its origins. Paper 2's purpose was to contribute to the wider debate regarding international collaborative digital curation provision. As such it takes a theoretical approach to exploring the ethics that underpin the main sub-disciplines of information science and how they affect collaborative efforts in the new digital paradigm. Paper 3's exploration of the intersection of the archives profession and digital curation was informed by work as a technical archivist specialising in metadata implementations prior to joining the DCC (see Appendix E). The Paper and subsequent poster (Figure 4-2), edited journal and workshop (see Appendix D.1) represent scoping activity for a wider funded project and arose out of a personal exploration of the intersection of archival principles in relation to the discovery of digital materials. This project has not yet been realised due to unexpected changes in the collaborators' employment statuses.

Archives context and discovery: hierarchy in the digital age

Are archival descriptive standards fit for purpose?

Sarah Higgins (sjh@aber.ac.uk) Department of Information Studies, Aberystwyth University
Christopher Hilton (c.hilton@wellcome.ac.uk) Wellcome Library, Wellcome Trust

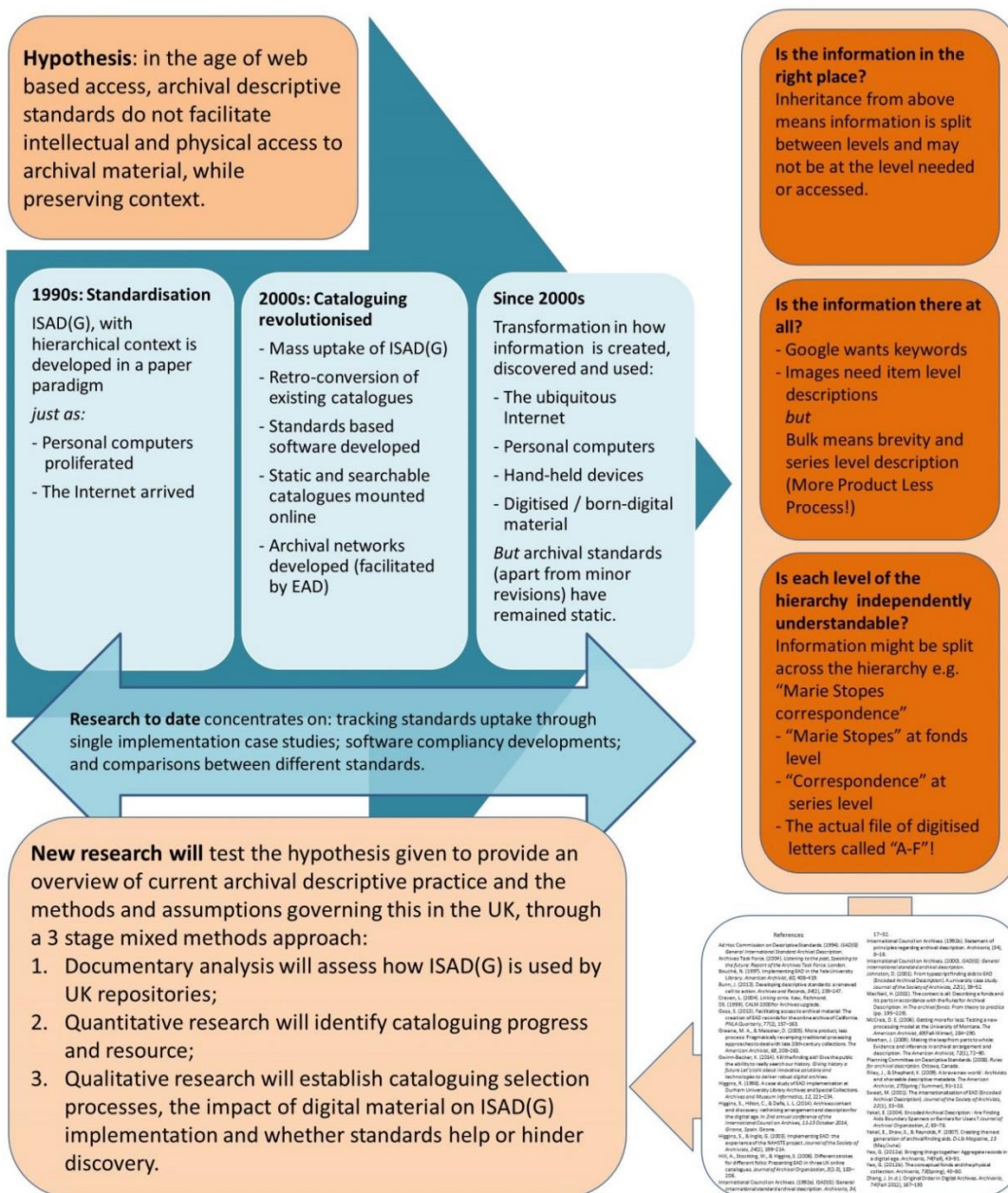


Figure 4-2: Poster presented at the International Council on Archives Conference 2015 (Higgins & Hilton, 2015)

4.2 Papers 4 and 5: Developing the conceptual model

Papers 4 and 5 bring together the professional activities that comprise digital curation into a theoretical conceptual model and offer a taxonomy to describe these. The papers arose from the DCC's requirement for a robust definition of what digital curation entails as a focus for its activities, as well as the wider professional community's need.

This 'urgent' need for 'a far-sighted set of cultivation actions' for the digital environment (Garrett & Waters, 1996, p. 40) was identified in the US in the late 1990s, where its *Task Force on Archiving of Digital Information* noted that:

'the digital world is still too new for us to describe fully the life cycle of the information objects that do now, or will in the future reside there'.

(Garrett & Waters, 1996, p.11)

In the UK the JISC funded *Warwick* workshops (see Paper 1) were the primary arena for setting the digital curation research agenda. Their recommendations relating to the need for a clear articulation of its activities can be seen in Table 4-1.

| Workshop number and date | Recommendations: Identification of digital curation activities |
|---------------------------------|--|
| 1995: Warwick 1 | <ul style="list-style-type: none">• Research current archival practice and their relevance to digital material.• Specification and formalisation of the preservation functions.• Develop and test a digital curation matrix• Development of permissive guidelines. (Marc Fresko Consultancy, 1996) |
| 1999: Warwick 2 | <ul style="list-style-type: none">• Testbed implementation for the draft OAIS standard. (Cedars Project, 1999) |
| 2005: Warwick 3 | <ul style="list-style-type: none">• Map of digital preservation processes so that the full lifecycle is understood, along with disciplinary differences to encourage collaboration and improve understanding of requirements, for policies and procedures and roles and responsibilities• Development of workflow systems and process definitions• Develop best-practice guidelines (Digital Curation Centre, 2005b) |

Table 4-1: Warwick Workshops: Recommendations on defining digital curation activities

Beagrie & Greenstein (1998) addressed *Warwick 1's* recommendations in a report for the JISC's eLib Programme.¹⁶ Their research defined a *digital resource lifecycle* which was later extended by Feeney (1999, pp. 26-27) (Figure 4-3).¹⁷

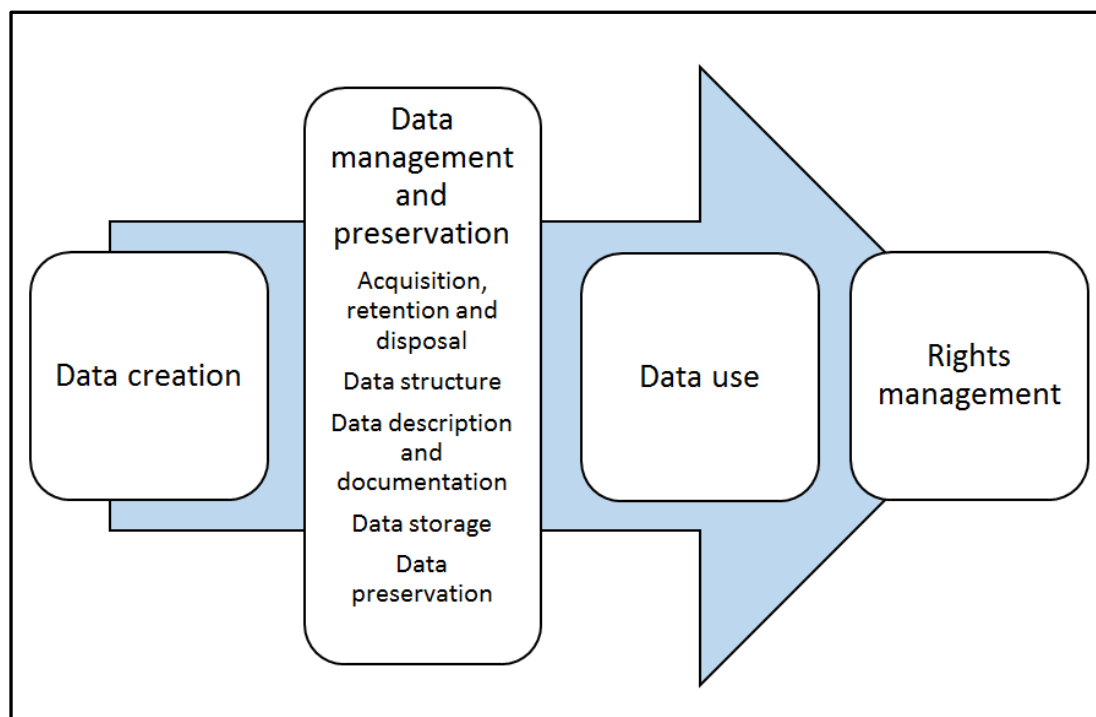


Figure 4-3: The digital resource lifecycle (after Beagrie & Greenstein, 1998 and Feeney, 1999)

Warwick 2 recommended a funded test-bed of the draft *Reference Model for an Open Archival Information System* (OAIS) from the space data community, to test its wider applicability to digital curation (Cedars Project, 1999). This, now influential standard ratified by the International Organization for Standardization (ISO), describes a technical workflow for digital preservation and ‘establishes a common framework of terms and concepts’ (Consultative Committee for Space Data Systems, 2002, p.iii). After testing the model *The Cedars Project*,¹⁸ also part of JISC’s *eLib Programme*, concluded that OAIS ‘presents a useful approach for the establishment of digital archives – particularly in a distributed environment – and also describes a standard vocabulary’ (Cedars Project, 2001). It has subsequently been widely recommended, adopted and

¹⁶ eLib Programme: <http://www.ukoln.ac.uk/services/elib/>

¹⁷ Arts and Humanities data Service (AHDS):
<https://web.archive.org/web/20160906080138/http://www.ahds.ac.uk:80/>

¹⁸ Cedars Project: <https://web.archive.org/web/20070607091736/http://www.leeds.ac.uk/cedars/>

critiqued (Allinson, 2006; Ball, 2006; Beedham, Missen, Palmer, & Ruusalepp, 2005; Egger, 2006; Knight & Hedges, 2007; Lavoie, 2000, 2014; Ruest, 2014; Schumann & Recker, 2013; Vardigan & Whiteman, 2007).

Warwick 3 was chaired by the Director of the DCC (previously Director of eLib) and discussions and conclusions regarding the need to map digital curation processes were most likely informed by the *IDCC (International Digital Curation Conference)* session he chaired two months earlier.¹⁹ Entitled *What is digital curation?*, participants agreed that a clear definition of professional activities were required for the operation of the DCC (Kerr et al., 2005).

It is within the above professional context that the author, employed as Standards Advisor at the DCC, mooted and was subsequently charged with leading the project to develop the DCC:CLM, to provide a planning tool and meet one of the funding work-package deliverables. This project was suggested and the research process informed by other concurrent professional duties including the development of *DCC DIFFUSE* (Paper 7), preparation of standards advisory material, and in particular:

1. Chair of the UK process to gather UK professional comments for ISO's 5 year revision of OAIS (Higgins & Boyle, 2008; Higgins & Semple, 2006; Kilbride & Higgins, 2009).
2. Member of the *International Users' Review Panel* for revision of the European Commission's *MoReq Specification – Model Requirements for the Management of Electronic Records* (Serco Consulting, 2008).

The DCC:CLM was developed over one year. Initially an internal project, iterative drafts were developed through desk research, focus groups and calls to a pool of 35-40 expert colleagues for comment. Once considered reasonably robust the final published draft (Paper 3) was publicised and wider professional comment solicited. Comments received were integrated into the draft before publication of the final model (Paper 4). The

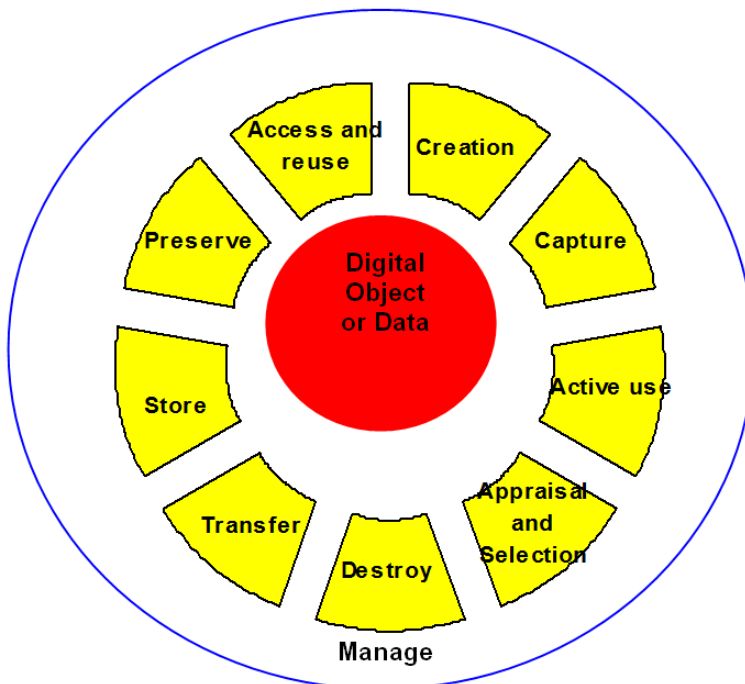
¹⁹ International Digital Curation Conference (IDCC): <http://www.dcc.ac.uk/events/international-digital-curation-conference-idcc>

timeline and details of the Project can be seen in Table 4-2, while the unpublished drafts of the graphic can be seen in Figure 4-4, Figure 4-5, Figure 4-6 and Figure 4-7.

| Date | Activity |
|-------------------|--|
| April - July 2007 | Desk Research to analyse scope of existing related models. Including the main professional standards: <ul style="list-style-type: none"> • OAI's • MoReq2, and • ISO 15489: Records Management. |
| July 2007 | 1 st staff focus group and requirements gathering exercise. Project aims identified: <ul style="list-style-type: none"> • Curation specific model to complement existing models e.g. OAI's; • Generic, extensible and adaptable high-level overview; • Organisational planning tool. |
| July – Oct 2007 | 6 iterative drafts prepared with help of 4 person working group responding to staff comments. |
| Oct 2007 | 2 nd staff focus group to brainstorm drafts. |
| Oct 2007 | 6 th draft distributed for staff comment. |
| Nov – Dec 2007 | Appropriate comments received and integrated into 7 th and final draft. Scope notes introduced at this point. Comments were excluded if: <ul style="list-style-type: none"> • Too specific; • Contradictory to accepted comments; • Assumed implementation of certain methods or standards. |
| Dec 2007 | <ul style="list-style-type: none"> • Draft (Paper 3) published for international comment. • Poster of draft presented and comments gathered at the <i>International Digital Curation Conference</i>. • Emails requesting comments sent to relevant mailing groups. • Discussion thread opened on the DCC's online forum. |
| Jan 2008 | Project report to staff. |
| Jan-April 2008 | All comments considered and integrated into the model. 10 comments were received, 5 of which, from experienced professionals, initiated substantial changes. These included: <ul style="list-style-type: none"> • Significant suggestions on the graphical presentation; • Revision of the order of sequential activities; • Use action <i>dispose</i> instead of <i>destroy</i>; • Repositioning of labels for clarity of meaning; • Addition of <i>Receive</i> and classification of <i>Occasional actions</i>. |
| March 2008 | Graphic artist engaged to improve presentation. |
| 1-4 April 2008 | Poster of draft presented and comments invited at the <i>Open Repositories Conference</i> . |
| 15 April 2008 | Soft launch of poster of final DCC:CLM at <i>JISC Conference 2008</i> . |
| June 2008 | Soft launch 2 poster reprised at <i>JCDL Conference 2008</i> . |
| June 2008 | Final DCC:CLM published (Paper 4). |
| December 2008 | Poster reprised at IDCC 2008, mousemats and leaflets distributed. |

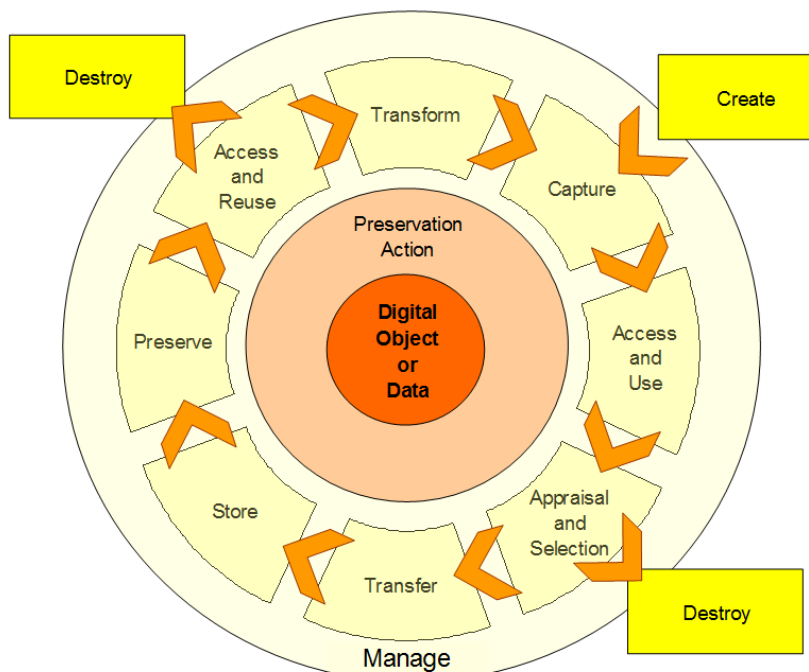
Table 4-2: The development timeline for the DCC Curation Lifecycle Model

Draft 1



- Sequential actions: first set of nine actions identified as a *petal model*.
- Full lifecycle actions: *manage* identified.

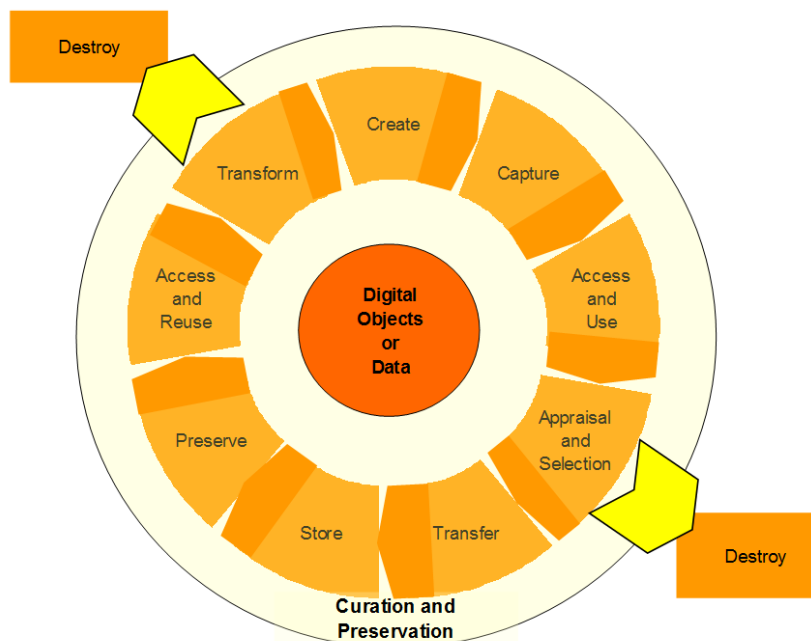
Draft 2



- Sequential actions: adds *access* and the arrows to show order of work; moves *create* to outside the circle.
- Full lifecycle actions: adds *preservation action*.
- Occasional actions: introduces these and removes *destroy* from the full lifecycle.

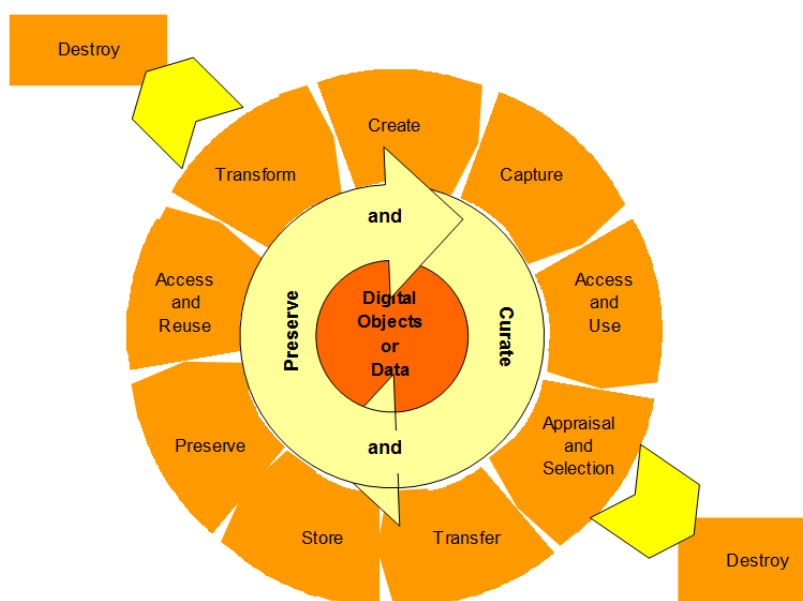
Figure 4-4: Drafts 1 and 2 of the DCC Curation Lifecycle Model

Draft 3



- Sequential actions: reintegrates *create*.
- Full lifecycle actions: renames *manage* and *preservation action* as *curation and preservation*.
- Occasional actions: no change.

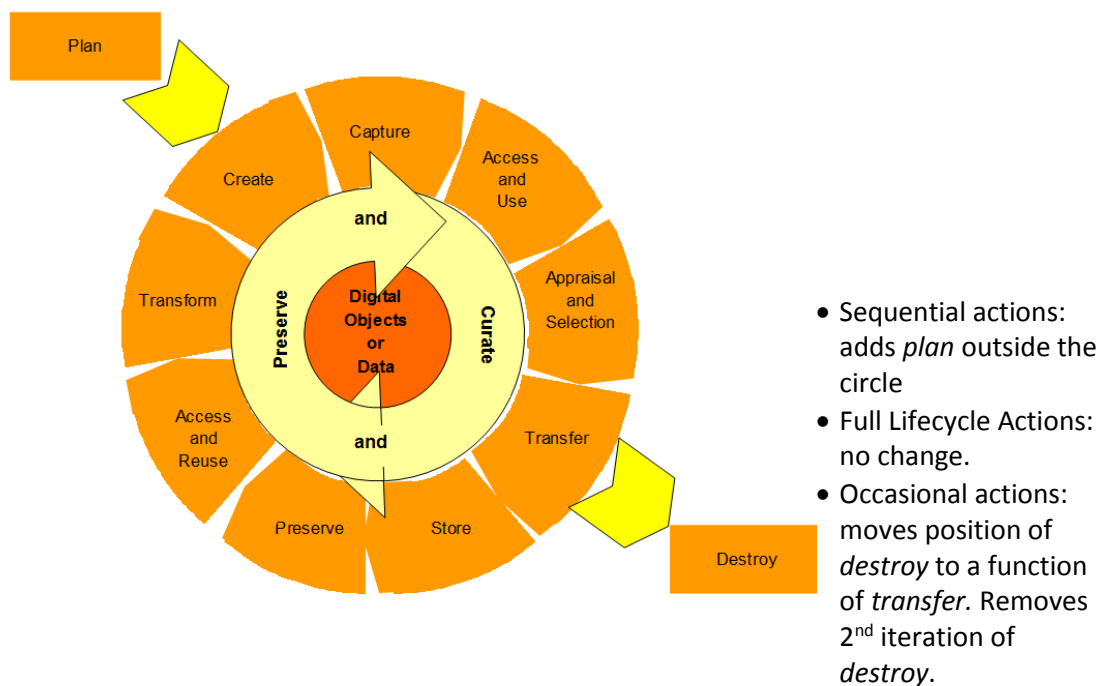
Draft 4



- Sequential actions: no change.
- Full lifecycle actions: introduces arrows to show interaction between *curate* and *preserve*.
- Occasional actions: no change.

Figure 4-5: Drafts 3 and 4 of the DCC Curation Lifecycle Model

Draft 5



Draft 6

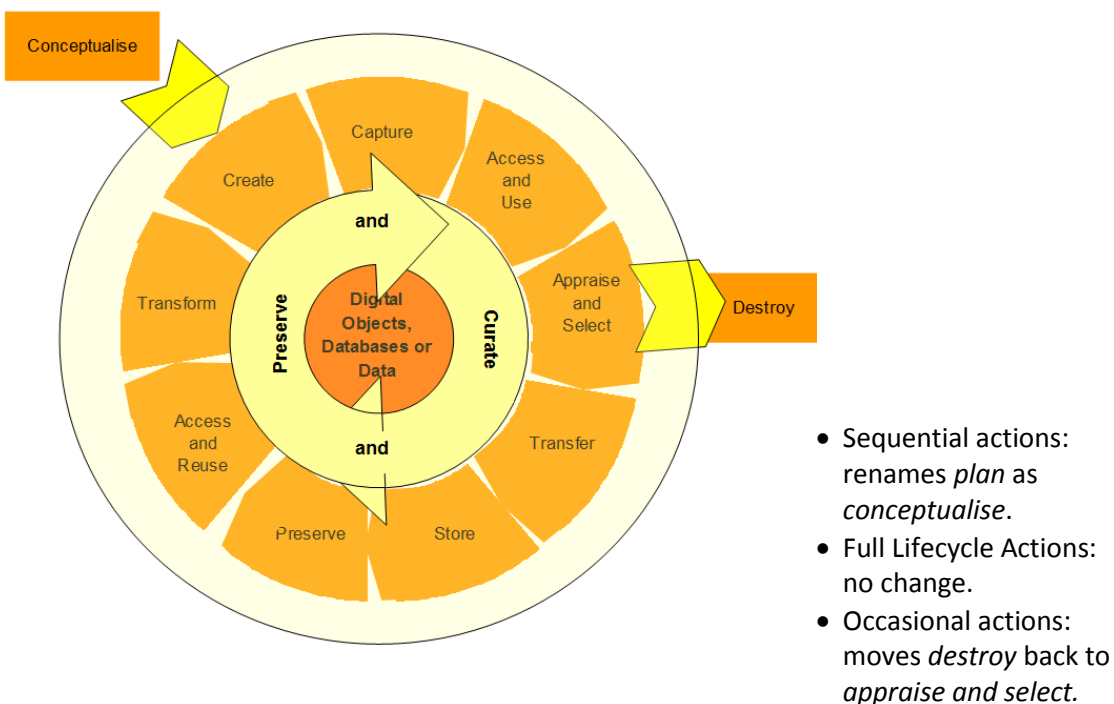
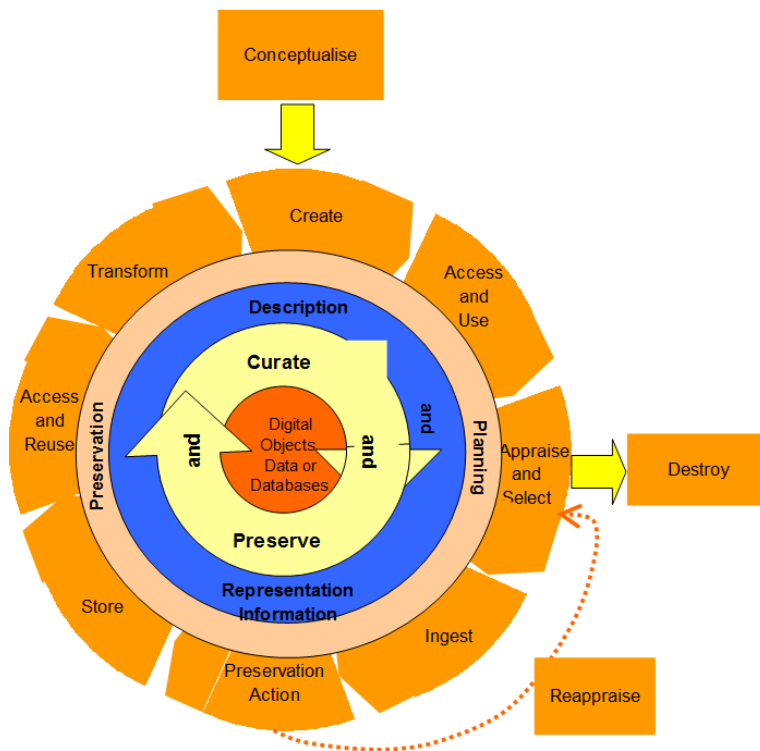


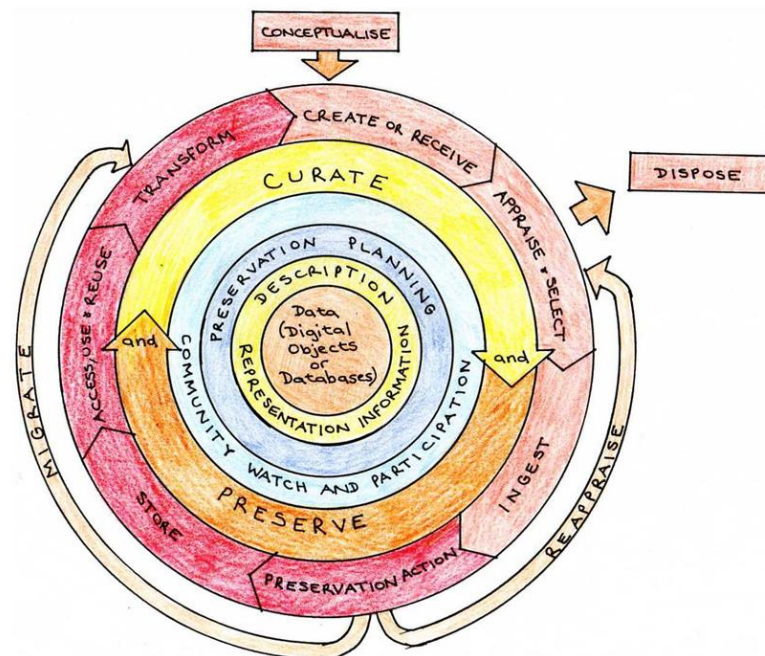
Figure 4-6: Drafts 5 and 6 of the DCC Curation Lifecycle Model

Draft 7 (Paper 4)



- Sequential actions: removes *capture*, adds *ingest*, moves position of *preserve* and renames as *preservation action*.
- Full lifecycle actions: adds *description and representation information and preservation planning*.
- Occasional actions: *destroy* becomes a function of *appraise and select*. Adds *reappraise*.

Draft 8 (Paper 5 – pre graphic artist!)



- Sequential actions: adds *receive*, removes first *access and use*.
- Full lifecycle actions: adds *community watch and participation*.
- Occasional actions: changes *dispose* to *destroy*, adds *migrate*.

Figure 4-7: Drafts 7 and 8 of the DCC Curation Lifecycle Model

As intended by the stated aims of the Project, the model was immediately adopted by the DCC to provide the main entry point to classify online resources for browsing (Paper 7) and to plan resources (Section 4.3). However it was also rapidly adopted both internally and externally for purposes not previously articulated, the latter causing a degree of surprise to the DCC:

- An analytic tool for digital curation implementations (Paper 6 and Sections 4.3); and
- A training tool to structure information and resources (Papers 8 and 9 and Section 4.4).

4.3 Paper 6 and 7: Testing and applying the conceptual model

Papers 4 and 5 demonstrated how the professional domain contributed to the development of the theoretical DCC:CLM. Papers 6 and 7 demonstrate the continuation of the academic to professional feedback loop (Figure 1-3) through the model's application to the analysis of existing professional practice and the classification of services. Both of Papers 6 and 7 also had their genesis in the *Warwick Workshops*.

Paper 6 presents one case-study of research data curation practice investigated by the *SCARP Project*. The need for case studies to analyse existing digital curation practices to better understand future needs were repeatedly articulated, particularly at *Warwick 2* where this was reiterated across themed recommendations (Table 4-3).

The *SCARP Project* was funded by JISC from 2007-2009 as part of its *e-Infrastructure Programme* to fill this recognised gap in knowledge. It used anthropological research methods to:

‘scope and carry out a programme of activities to get a better understanding of discipline-specific requirements and their impact on data curation, and to promote effective data curation practices tailored to suit the disciplinary needs of the researchers’ (JISC, 2007)

| Workshop number and date | Recommendations: Case studies |
|--------------------------|--|
| 1995: Warwick 1 | <ul style="list-style-type: none"> Investigate data creators' attitudes on responsibilities for archiving digital materials. <p>(Marc Fresko Consultancy, 1996)</p> |
| 1999: Warwick 2 | <ul style="list-style-type: none"> UK survey of practice (adapting the US's Research Libraries Group's survey (Hedstrom & Montgomery, 1998)) Understand the digital preservation needs of different sectors Case studies (good practice and bad) Undertake analysis of resource for digital preservation and problems encountered in undertaking it Understanding why/how organizations are involved in digital curation at different stages of lifecycle Develop and test a digital curation matrix <p>(Cedars Project, 1999)</p> |
| 2005: Warwick 3 | <ul style="list-style-type: none"> A clearer understanding of the needs of diverse disciplines and encouragement for cross-disciplinary programmes is required <p>(Digital Curation Centre, 2005b)</p> |

Table 4-3: Warwick Workshops: Recommendations for case study development

Like the previously published *CARMEN Project's* study of neuroscience data curation (Pryor, 2008),²⁰ *SCARP* recognised the DCC:CLM as a tool to structure empirical analysis of the digital curation matrix across the study organisations' data lifecycles.

The application of the DCC:CLM to understanding current practice and future strategy was also quickly identified by bodies external to the DCC. Table 4-4 shows published examples of the model's implementation in the first 18 months after its release (Higgins, 2009), with one commenting on the *Digital Curation Blog* 'the DCC lifecycle was indeed a valuable input to the second stage of the UK Research Data Service (UKRDS) study' (Beagrie, 2008).

| Organisation | Implementation of the DCC Curation Lifecycle Model |
|--------------|--|
|--------------|--|

²⁰ CARMEN Project:
https://web.archive.org/web/20170201194307/http://www.carmen.org.uk/?page_id=251

| | |
|--|---|
| Developmental Gene Expression Map (DGEMap) | EU funded study to develop a large scale human gene-expression atlas used the DCC:CLM as a tool to model their curation needs (Donoghue & Hemert, 2009). |
| Digital Libraries Curriculum Development and DigCCurr projects | Development of digital library and curation curricula in US universities (Pomerantz, Oh, Wildemuth, Hank, & Tibbo, 2009). |
| Embedding Digital Curation Services in Research (EIDCSR) Project, Oxford Research Groups | Developing policy, workflow and sustainability for research data curation and management (Martinez-Urbe, 2009b). |
| Florida State University Libraries and Digital Library Center | Planning curation of digital objects for an online digital collection (Smith, 2009). |
| InSPECT Project | To validate the methodology used to determine the significant properties of a digital object in the InSPECT Project (Grace, Knight, & Montague, 2009). |
| Key Perspectives Ltd (report for JISC) | Identified data scientist roles to recommend training developments needed (Swan & Brown, 2008). |
| Oxford University Digital Repositories Steering Group | Benchmarking and validating activities and workflow for a planned research data management and curation service (Martinez-Urbe, 2009a). |
| South African Council for Scientific and Industrial Research (CSIR) | Recommended as the strategic basis of a digital curation and preservation strategy (Merwe & Deventer, 2009). |
| UK Research Data Service | Identifying required contents of research data management plans in the feasibility study for establishing a UK wide research data service (UK Research Data Service, 2009). |

Table 4-4: Examples of DCC:CLM implementations in 2008-2009 (after Higgins, 2009)

Community take-up of the DCC:CLM meant that it rapidly became, and continues to be, a *de facto* standard for describing the activities involved in digital curation and analysing implementations. Although some argue its unreliability (Kulkarni, Aziz, Shams, & Busse, 2009; Yang & Meho, 2006), Google Scholar is a readily available and increasingly used tool. In August 2017 it identified 216 academic citations to Paper 5 and an additional 27 citations to Paper 4 (Figure 4-8). Further citations pointed to the one page primer on the DCC's website where organisational rather than personal attribution is given.²¹

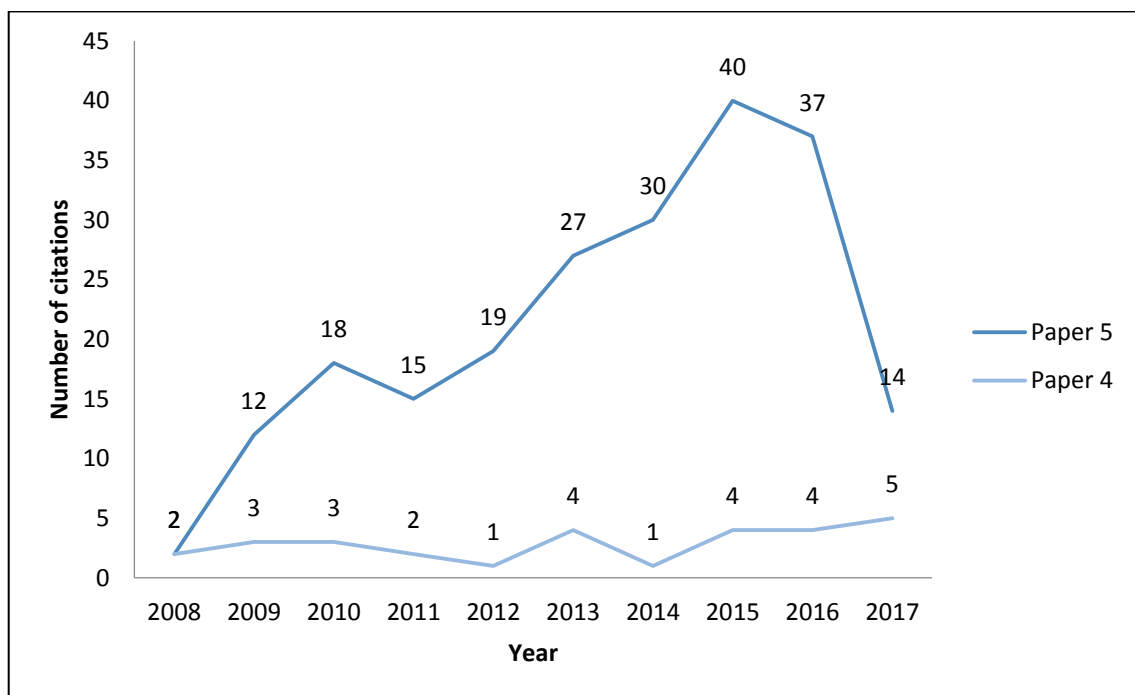


Figure 4-8: Google Scholar citations to the DCC Curation Lifecycle Model

The model has considerable reach beyond formal academic citation, although this is very difficult to quantify, it being frequently presented at professional conferences and training events and embedded into research and educational materials. Purposive representative examples of recent applications identified from blunt research through a Google Image keyword search can be seen in Figure 4-9, Figure 4-10 and Figure 4-11, while recent mentions on Twitter can be seen in Figure 4-12 and Figure 4-13.

²¹ DCC Curation Lifecycle Model: <http://www.dcc.ac.uk/resources/curation-lifecycle-model>

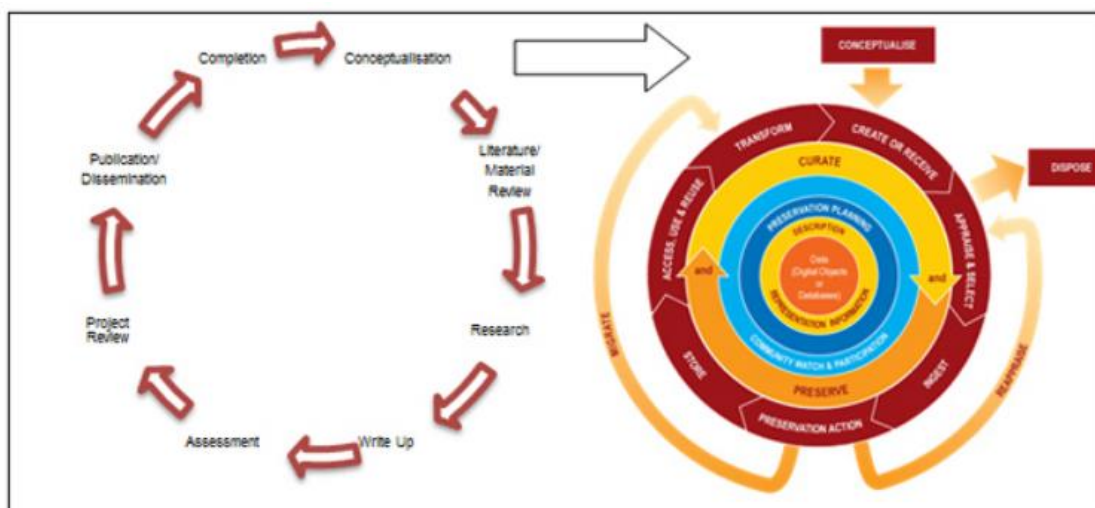


Figure 4-9: Research training materials (Portsmouth University Postgraduate Online Research Training, 2013)

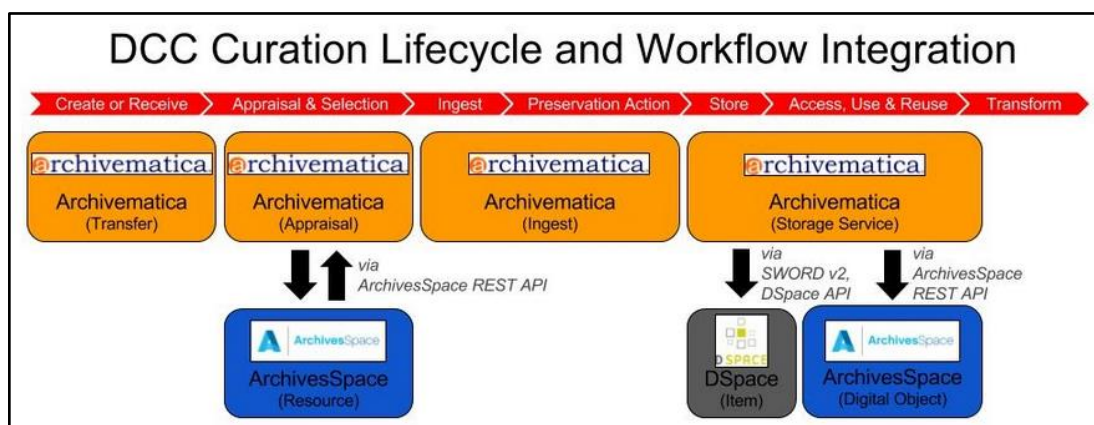


Figure 4-10: Planning software development (Eckard, Pillen, & Shallcross, 2017)

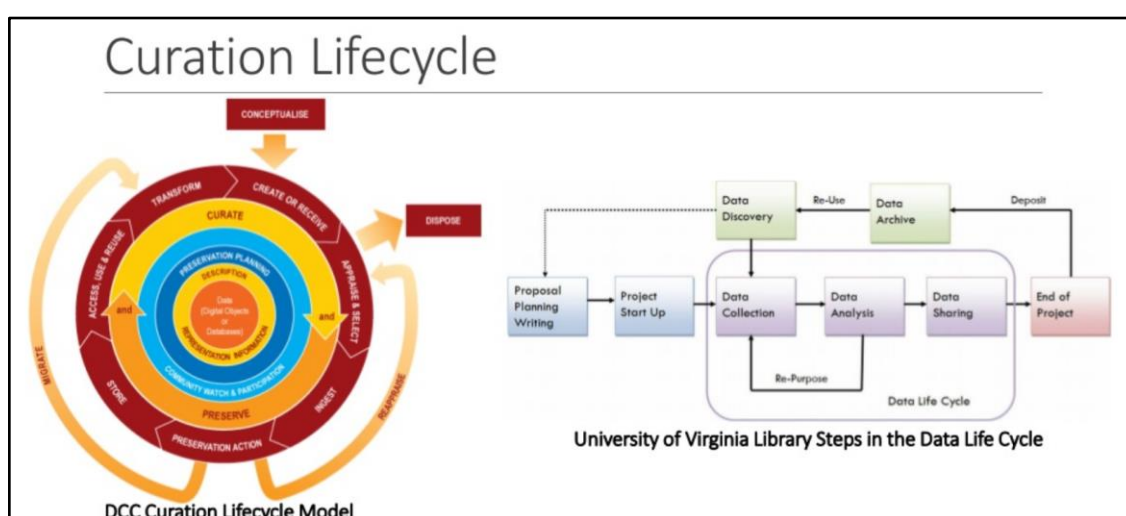


Figure 4-11: Planning research data management services (J. Lee, 2016)



Figure 4-12: Recent mentions of the DCC:CLM on Twitter (1)

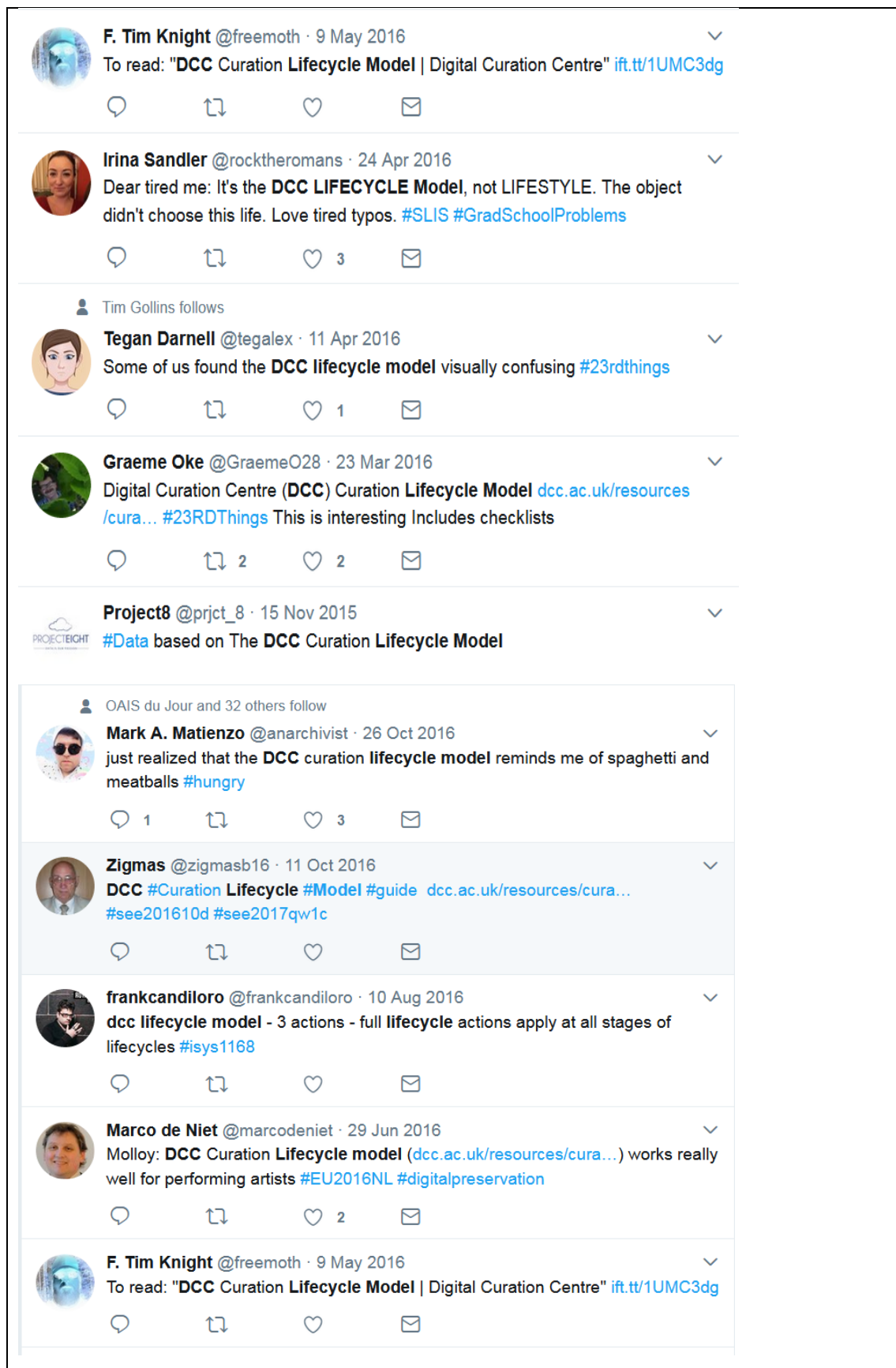


Figure 4-13: Recent mentions of the DCC:CLM on Twitter (2)

Paper 7 presents an application of the DCC:CLM to the organisation of a standards advisory tool. The genesis of this tool in the *Warwick Workshops* can be seen in Table 4-5 where the link between standards compliance and available information about standards was made.

| Workshop number and date | Recommendations: Tools register |
|--------------------------|---|
| 1999: Warwick 2 | <ul style="list-style-type: none"> • Funding dependency on standards compliance • Information gap regarding available standards and technologies <p>(Cedars Project, 1999)</p> |
| 2005: Warwick 3 | <ul style="list-style-type: none"> • Establish a standards framework • Standardised registry/repositories for representation information, metadata and curation tools to facilitate sharing and encourage standards adoption • More best practice guidelines <p>(Digital Curation Centre, 2005b)</p> |

Table 4-5: Warwick Workshops: Recommendations for development of a tools register

Originally *DCC DIFFUSE* was conceived as an update of a catalogue of ICT standards created by the moribund EU 5th Framework Programme Project *DIFFUSE* (Higgins, 2006).²² However, it was rapidly realised that domain specific advice, in frameworks of interoperable standards, more explicitly focused on digital curation was needed.

Metadata for three frameworks was fully completed and a front-end search using the DCC:CLM developed before the DCC's funding priorities changed and support for the project was discontinued.

²² DIFFUSE (Dissemination of InFormal and Formal Useful Specifications and Experiences to Research, Technology, Development and Demonstration Communities):
<http://cordis.europa.eu/ist/ka3/iaf/projects/diffuse.htm>

Existing published frameworks documented were:

- *MoReq2's* framework for records management (enabled through membership of the *International Users' Review Panel*); and
- *The Driver Project's* framework for digital repositories (Foulonneau & Francis, 2007).²³

A bespoke framework for archival science was developed in collaboration with the ARA *Data Standards Group Committee*,²⁴ of which the author was a member. This framework was presented at the ARA Conference 2008. Articles featuring individual standards in the framework were authored and/or co-ordinated and published in *ARC* and online from 2007-2011 (Archives and Records Association, n.d.).

Additional scoping work undertaken but not implemented included:

- Negotiations with other relevant disciplinary bodies for new frameworks. These included:
 - Digital libraries: The JISC Standards Catalogue;²⁵
 - Engineering test data: through the author's membership of the European Committee for Standardization's (CEN) *Workshop on standards and ontologies for materials test data* (European Committee for Standardization, 2010).²⁶
 - Geographic information standards: Open GIS Consortium standards.²⁷
- Use of *DCC DIFFUSE* as the metadata front end for the DCC's developing *Registry Repository of Representation of Representation Information* (RORRI), which would store the technical specifications for standards; and
- Initiation of crowdsourcing information through *Wikipedia*.

²³ DRIVER II: http://cordis.europa.eu/project/rcn/86426_en.html

²⁴ Now the ARA Section for Archives and Technology: <http://www.archives.org.uk/about/sections-interest-groups/archives-a-technology.html>

²⁵ JISC Standards Catalogue (no longer online): <https://web.archive.org/web/20130227035221/http://standards.jisc.ac.uk/catalogue/Home.phtml>

²⁶ European Committee for Standardization (CEN): <https://www.cen.eu/Pages/default.aspx>

²⁷ Open GIS Consortium (OGC): <http://www.opengeospatial.org/>

The DCC also adopted the DCC:CLM to other advisory functions. Colleagues undertook a gap analysis of existing policy advisory services by mapping these against the model to help determine tools development (Figure 4-14) (Jones, 2008); meanwhile the website's resources were reorganised to reflect the DCC:CLM's set of activities.

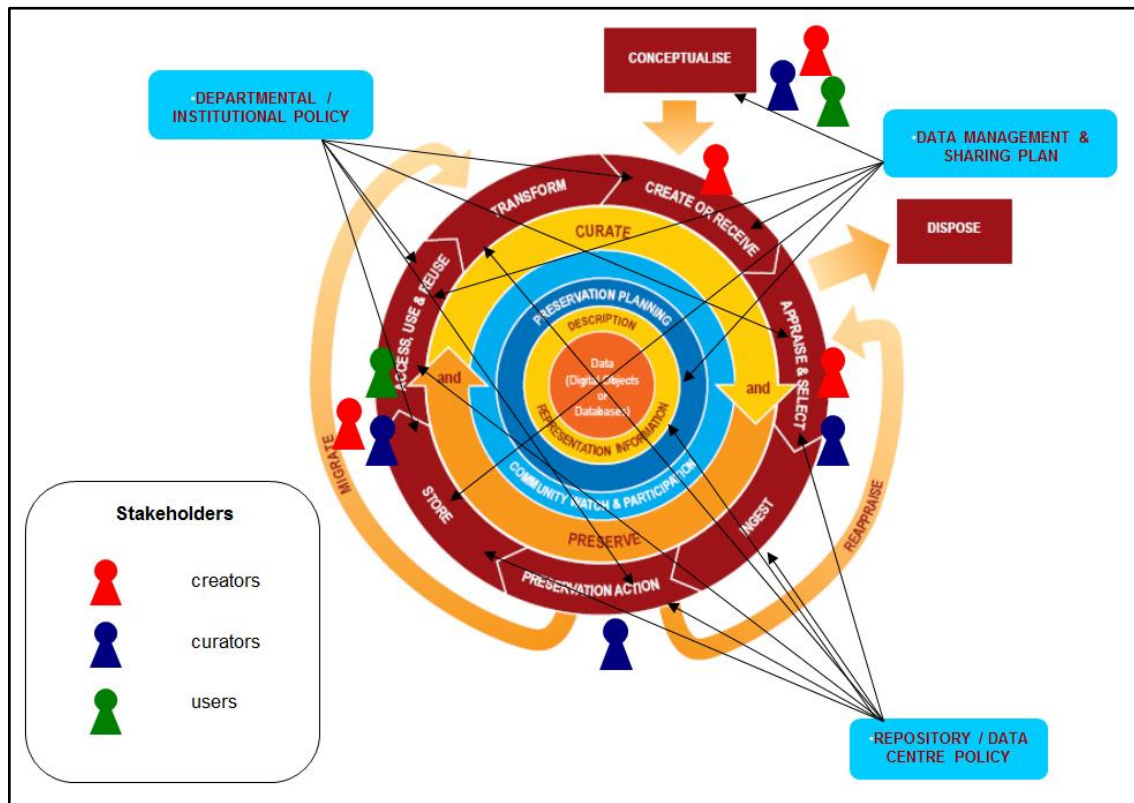


Figure 4-14: Policy advice gap analysis for the DCC (Jones, 2008)

4.4 Papers 8 and 9: Elaborating the conceptual model

Papers 8 and 9 contribute an elaboration of the theoretical DCC:CLM into detailed guidance on professional best practice for digital curation implementation. Although written while employed by Aberystwyth University, these papers were informed by: Papers 4 to 7, the professional context of the DCC described in Sections 4.2 and 4.3, and DCC training activities undertaken.

The DCC:CLM was not developed to support the DCC's core training activities, but was identified as the missing framework for structuring these during the concurrent

development of the *Digital Curation 101* (DC 101) course.²⁸ Initial workshops structured around the DC:CLM were developed, with some help from two colleagues, and delivered by the author as proof of concept at two major information science conferences in 2008: The Joint Conference on Digital Libraries (JCDL)²⁹ and IDCC. The latter led to an invitation by the MetaArchive Co-operative³⁰ to the 2009 *Community approaches to digital preservation conference*:

‘A highlight of the meeting was a presentation by Sarah Higgins of the Digital Curation Centre, who provided an abbreviated workshop outlining the DCC Curation Lifecycle Model. The model is intended as tool for use in conjunction with relevant standards to plan curation and preservation activities.’

(Library of Congress, 2009)

DC 101, a one day training course for continuing professional development, also used the DCC:CLM as its primary structure. Developed in parallel by another colleague, the two activities informed and cross-fertilised each other through joint content research and collaboration. DC 101 incorporated:

- An overview of roles and responsibilities for lifecycle actions;
- Case studies of DCC research such as *CARMEN* and *SCARP*;
- Training on the use of tools developed by the DCC e.g. DRAMBORA,³¹ Data Asset Framework (DAF)³² and DMPOnline;³³

²⁸ DC 101: <http://www.dcc.ac.uk/training/train-the-trainer/dc-101-training-materials>

²⁹ Joint Conference on Digital Libraries (JCDL): <http://www.jcdl.org/>

³⁰ MetaArchive Cooperative: <https://metaarchive.org/>

³¹ DRAMBORA (Digital Repository Audit Method Based on Risk Assessment) – a data risk assessment tool developed by the DCC and Digital Preservation Europe (DPE): <http://www.repositoryaudit.eu/>

³² DAF (Data Asset Framework) – a data audit tool: <http://www.dcc.ac.uk/resources/tools/data-asset-framework>

³³ DMPOnline (Data Management Plans Online) – a management planning tool: <https://dmponline.dcc.ac.uk/>

- Local case studies drawn from host organisations.

DC 101 was piloted in Edinburgh in October 2008 and a *lite* version delivered at *IASSIST*³⁴ in 2009. Thereafter it was rolled out as a stock training activity. The author developed individual presentations and activities and participated in the delivery of the course, being asked to continue delivering it for a few months after leaving the DCC.

Papers 8 and 9 represent the foundational chapters in two textbooks for professional training in digital curation in an academic environment. These chapters incorporated the knowledge gained from preparing DC 101 with that gained while employed at Aberystwyth University.

Practically the author has been working as a member of the *Archives and Records Council Wales Digital Preservation Group* (ARCW DP) since 2010,³⁵ on a project to develop a co-operative digital preservation service for Wales, that was shortlisted for the 2014 Digital Preservation Awards (Digital Preservation Coalition, 2014c). As well as technical and organisational oversight of the project, work has included the co-authoring of a business case for the Welsh Government's Department of Museums, Archives and Libraries (MALD) to secure funding for the Project (Burns, Higgins, Phillips, Tuson, & Whitehead, 2010) and editorial oversight of the development of the *Digital Preservation Policy for Wales* (including the Technical Appendix) to underpin further work (Archives and Records Council Wales Digital Preservation Group, 2017).

Academically the author was extending the curriculum to enable students across the master's courses to study digital curation. She inherited a 10 credit master's module in

³⁴ International Association for Social Science Information Services and Technology (IASSIST): <http://www.iassistdata.org/conferences>

³⁵ Archives and Records Council Wales (ARCW): <https://archives.wales/>

Digital Information while Paper 8 was being written,³⁶ so that lectures for full-time delivery were being redeveloped and the corresponding distance learning materials being completely revised. Paper 9 further benefitted from the research and preparation to introduce specific education on digital preservation into the master's curriculum, for cross-course delivery, from 2013 and the research and preparation of: the underlying syllabi, lectures for the new full-time module, and learning resources for distance learners.³⁷ These modules have recently been rolled out as stand-alone courses for continuing professional development.³⁸

4.5 Paper 10: Developing the digital curation curriculum

Paper 10 contributes a five level theoretical and technical competency framework for higher education in digital curation. This, along with work undertaken at the DCC, informed the module development discussed in Section 4.4 and contributed to the curriculum for Aberystwyth University's *MSc in Digital Curation*.³⁹ As no UK *Quality Assurance Agency*⁴⁰ benchmarking statement exists for digital curation as a discipline (Higgins, 2017) the MSc's curriculum derived its competencies from the findings of successive projects to identify these; all of which used the DCC:CLM as a baseline while building upon each other (Figure 4-15). The textbook initially chosen to support digital curation master's studies was independently structured around the DCC:CLM following the book's author undertaking a research fellowship with the DCC (Harvey, 2010).

The curriculum developments allowing all students to study either digital preservation or digital curation were shortlisted for the 2014 Digital Preservation Awards along with

³⁶ ILM7510 Digital Information Discovery to Delivery (full-time now discontinued) and DSM7510 Digital Information Discovery to Delivery (distance-learning):

<https://www.aber.ac.uk/en/modules/deptcurrent/DSM7510/>

³⁷ ILM7420 incorporates ILM7510 and an additional semester's teaching on digital preservation (full-time): <https://www.aber.ac.uk/en/modules/deptcurrent/ILM7420/>. DSM6010 introduces digital preservation for distance learners: <https://www.aber.ac.uk/en/modules/deptcurrent/DSM6010/>

³⁸ Short courses for continuing professional development: <https://www.aber.ac.uk/en/dis/short-courses/#our-courses>

³⁹ MSc Digital Curation offered fulltime (<https://courses.aber.ac.uk/postgraduate/digital-curation-masters/>) or by distance learning (<https://courses.aber.ac.uk/postgraduate/digital-curation/>)

⁴⁰ The Quality Assurance Agency for Higher Education: <http://www.qaa.ac.uk/en>

individual master's dissertations supervised by the author shortlisted in both 2014 and 2016 (Digital Preservation Coalition, 2014a, 2014b, 2016b).

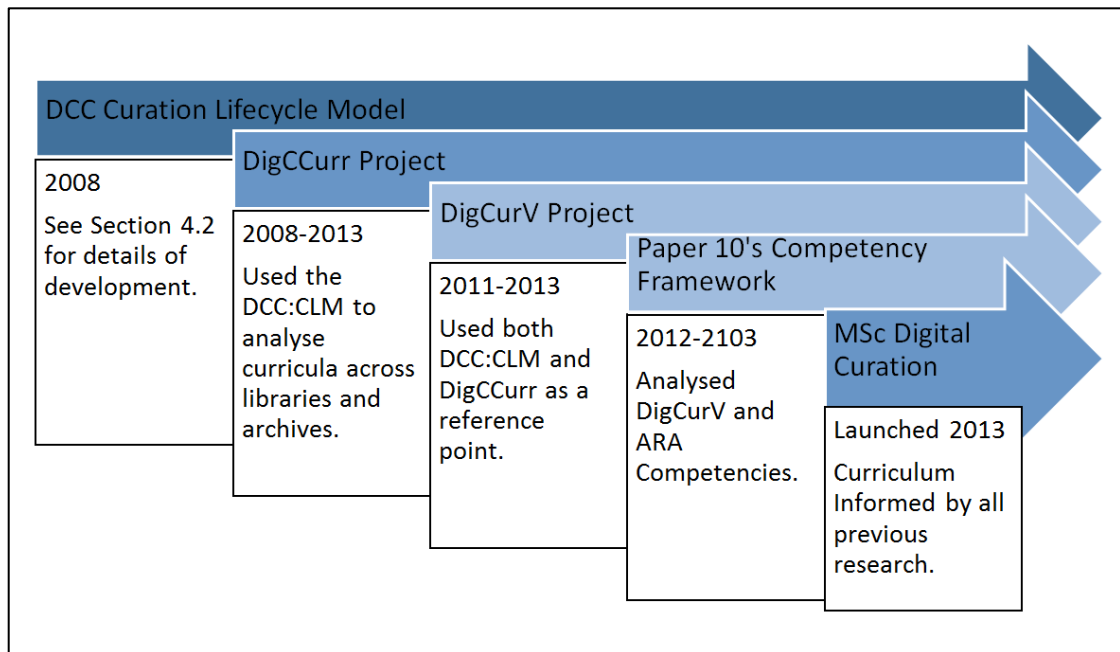


Figure 4-15: Iteratively identifying the digital curation curriculum (Bunn & Higgins, 2013; Higgins, 2008; Karvelyte et al., 2012; Pomerantz, Wildemuth, et al., 2009; Williams, 2012)

4.6 Contributions to academic research

Sections 4.1 to 4.5 discussed the wider professional context in which each of the author's academic papers were written and their impact primarily on professional practice. This section considers the contribution the papers have made to the academic dimension of digital curation, and their role in the academic to professional feedback loop, through a quantitative and qualitative analysis of their citations. Figure 4-8 identifies the number of Google Scholar identified citations for Papers 4 and 5 in August 2017. This section will use Google Scholar to identify both the number of citations to all 10 papers, from the date of publication to the end of December 2017, and analyse where the work has been cited. Figures were obtained from Google Scholar in March 2018 and differ slightly from those available in August 2017.

The total citations identified for each paper per year and for the whole body of work per year can be seen in Table 4-6. Table 4-6: Number of citations to each paper listed by date of publication. As can be seen a total of 378 citations have been made, and these works have, in turn, been cited a total of 2411 times. Paper 5 is the most heavily cited with a total of 230 citations (61%) and Paper 1 is the second most cited with 75 citations (20%). Papers 8 and 4 have 25 (7%) and 28 (7%) citations respectively. Three of the papers, Papers 6, 9 and 10 have had no citations at all! Paper 6 was produced as part of a project that responded directly to an identified need for case studies in digital curation, so its lack of citations is surprising. It's publication on the SCARP Project page on the DCC's website, rather than in a journal or conference proceedings might have hampered its visibility. Similar visibility issues may relate to Paper 10, which is included in proceedings for the DigCurV Project's final conference, and again is primarily available on the Project's website. Paper 9 may not yet have been picked up by Google Scholar as it is a more recent publication in a physical book rather than online. Total citations follow the trajectory of Paper 5, the most cited paper (Figure 4-8), steadily rising between 2008 and 2015 before starting to reduce again.

| Year | Paper number and year of publication (chronological) | | | | | | | | | | Citation total (per year) |
|----------------------------|--|-------------|-------------|-------------|-------------|-------------|-------------|--------------|-------------|-------------|---------------------------|
| | 4 (2007) | 5 (2008) | 6 (2009) | 7 (2009) | 1 (2011) | 8 (2012) | 2 (2013) | 10 (2013) | 3 (2014) | 9 (2016) | |
| 2007 | 0 | | | | | | | | | | 0 |
| 2008 | 3 | 3 | | | | | | | | | 6 |
| 2009 | 3 | 12 | 0 | 0 | | | | | | | 15 |
| 2010 | 3 | 16 | 0 | 0 | | | | | | | 19 |
| 2011 | 2 | 15 | 0 | 2 | 0 | | | | | | 19 |
| 2012 | 1 | 20 | 0 | 0 | 10 | 0 | | | | | 31 |
| 2013 | 4 | 27 | 0 | 0 | 13 | 2 | 0 | 0 | | | 46 |
| 2014 | 1 | 31 | 0 | 1 | 12 | 4 | 1 | 0 | 0 | | 50 |
| 2015 | 5 | 43 | 0 | 2 | 17 | 6 | 2 | 0 | 3 | | 78 |
| 2016 | 5 | 36 | 0 | 2 | 11 | 9 | 0 | 0 | 3 | 0 | 66 |
| 2017 | 0 | 25 | 0 | 0 | 12 | 4 | 2 | 0 | 2 | 0 | 45 |
| Citation total (per paper) | 28 | 230 | 0 | 7 | 75 | 25 | 5 | 0 | 8 | 0 | 378 |
| Citations to citing papers | 268 | 1666 | 0 | 30 | 336 | 101 | 8 | 0 | 2 | 0 | 2411 |

Table 4-6: Number of citations to each paper listed by date of publication

Citations are primarily in articles in academic journal, but conference proceedings, books and posters are also represented as well as 10 PhDs and 3 Master's dissertations. Author's affiliations were mostly in Western Europe, North America and Australasia, but 9% (34/378) are written in Chinese. Individual countries such as Ukraine, Hungary, Turkey, Kuwait, South Africa, Russia, Kyrgyzstan and Brazil are all represented, but India is notably missing. Analysis of the citations shows that different papers are reaching different communities within traditional information sciences disciplines. Those with the lowest citations are reaching a more niche audience than those with a higher number of citations. Papers 2 and 3 are primarily cited by academic researchers concerned with the primary focus of the paper: joint working across LAMs, and archival principles and cataloguing methods respectively. 4 out of 7 of Paper 7's citations arise from one researcher's PhD and subsequent publications! Paper 8's citations mostly relate to case studies of research data management implementations – not surprising as it was a chapter in a book entitled *Managing Research Data*. About half of these address general organisational strategy; while half relate to managing specific data

genres such as bio-collections, health data, astronomical data, geographical data and personal digital archives. Papers 4 and 5 reach a much wider cross-section of information science disciplines and concerns covering issues such as implementation case studies, archival theory, training and curriculum development, standards development, knowledge architecture, metadata and ontologies, file formats etc. Paper 1 showed the greatest reach beyond the information science disciplines with citations to theoretical pieces from researchers in disciplines such as art history, music, psychology, geography and palaeontology; showing perhaps that the concept of digital curation, is becoming a cross-disciplinary concern.

5. Reflection and next steps

The previous chapters have indicated the significance of the author's contribution to the successive definition of digital curation as a distinct discipline within the information studies domain, and the professional and academic contexts in which these contributions were made. This chapter will identify the gaps in research that would build on these works to further reinforce the academic to professional feedback loop for the discipline in three core areas:

1. Improving the discovery of digital archives through implementation of the research project scoped in Paper 3 (and subsequent related work detailed in Section D.1);
2. Testing and extending the DCC:CLM through an analysis of the ecosystem of digital humanities data; and
3. Continuing the progressive professional development of the discipline through examination of ethics, competencies and accreditation for individual digital curation practitioners.

5.1 Improving discovery of digital archives

Paper 3 outlines how digital archives are hostage to the contextual and provenancial principles used to arrange and catalogue them hampering their discovery. The publication of the draft archival description reference model *Records in contexts* (RiC-CM) (International Council on Archives Expert Group on Archival Description, 2016), which expands the traditional understanding of provenance and provides an information model and related ontology for semantic technologies, has changed the metadata landscape described in Paper 3. Rather than top-down cataloguing of an archival collection it will enable multi-directional inter-relationships to be described (Pitti, Stocking, & Clavaud, 2016), solving some of the issues highlighted by Paper 3. RiC-CM has not yet made any professional leeway, possibly because of its conceptual complexity and the lack of tools to implement it. However, continuing with the projects

outlined in Paper 3 and testing the hypothesis posed in Figure 4-2 may prove to be the required entry point for testing the RiC-CM and challenging professional status-quo.

5.2 Testing and extending the DCC:CLM

The DCC:CLM 'is not definitive and will undoubtedly evolve' (Higgins, 2008, p. 136). It has certainly not gone un-critiqued. Within months of the publication of Paper 5 a proposed extension to the model was published (Constantopoulos et al., 2009) and the author has already put forward her own suggestions for improvement that adds concepts of value and financial investment (Rusbridge, 2011). There is also an argument for an executive layer that lies beyond the curator's domain including issues such as ethics and legal considerations. OAIS continues to offer an industry level standard that is informing software developments, implementation management and repository accreditation standards (International Organization for Standardization, 2009; Knight & Hedges, 2007; NESTOR Working Group Trusted Repositories - Certification, 2009; Pyrounakis, Nikolaidou, & Hatzopoulos, 2014; University of Hull, Yale University, University Of Virginia, & Stanford_University, 2012), although it is now more critically received by the community than in the past (Digital Preservation Coalition, 2016a) . Papers 6 and 7 used the DCC:CLM as an analytical tool, but they did not evaluate it. Numerous data lifecycle models, some influenced by the DCC:CLM have been proposed that offer a different set of tasks for digital curation (NTU Libraries, n.d.; Santa Cruz University Library, n.d.; Smith, 2017; United States Geological Survey, 2017; University of Nottingham, n.d.); while a number of works offer comparative evaluation of the different models offered (Ball, 2012; CEOS Working Group on Information Systems and Services, 2012; CLIF Project, 2010; L'Hours, 2014). Most of these works focus on research data management, representing one sub-discipline of information science.

An evaluation of the DCC:CLM that examines both the organisational structures and information architecture surrounding the curation of the heterogeneous data-sets created by the digital humanities would build directly on papers 4 to 9. This area of data creation has had less attention to date than research data. A case study of Wales would

feed directly into the next phase of the ARCW *Digital Preservation Project*, which is currently focussed on born-digital records and archives.

5.3 Professionalising the discipline

Digital curation has moved through the seven stages of discipline development identified in Figure 1-1 so that higher education is now offered by an increasing selection of universities. The author's work presented here has contributed to this process through analysing and modelling digital curation's conceptual space and enabling higher education provision. However, digital curation is not yet recognised as a profession in its own right in that there is no:

- Ethics statement to underpin the discipline's core mission;
- Recognised badge of competence underwritten by the professional organisations that represent it, such as the registration status conferred by Chartered Institute of Library and Information Professionals (The Library and Information Association) (CILIP)⁴¹ or ARA; or a
- Set of competencies or academic curricula underwritten by a professional organisation.

This additional step in developing the discipline so that it becomes a recognised *PROFESSION* was highlighted by the author in a recent blog post for the DPC (Higgins, 2017). This is the primary cross-sectoral support organisation which could continue to support digital curation through a metamorphosis into a profession in the UK. The research required to enable this progression, particularly an enshrining of professional ethics, is being scoped by the author through membership of the DPC and in particular their *Workforce Development Committee*.

⁴¹ Chartered Institute of Library and Information Professionals (The Library and Information Association) (CILIP): <https://www.cilip.org.uk/>

5.4 Conclusion

Nearly all academic research needs to be underwritten by research funding, as only so much can be achieved without additional resource. The author is actively investigating projects in the areas outlined above and researching suitable funding streams with appropriate collaborators. However, competition for funding is fierce and receipt of such is not only dependent on the merits of the proposal but also on the current priorities of the funding body: so it is by no means certain that funding will be acquired to progress the plans outlined above. Meanwhile teaching and administrative workloads in higher education are increasing in the UK's competitive market and the dawn of the Teaching Excellence Framework (TEF)⁴², making time for research harder to accommodate.

Despite this environment the author is committed to building on the work achieved to date and continuing to contribute to the development of digital curation as a discipline and also its future development into a profession in its own right.

⁴² Teaching Excellence Framework (TEF): <http://www.hefce.ac.uk/lt/tef/>

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<http://doi.org/10.1002/asi.20507>

7. Appendices

Appendix A: List of submitted published works

| Section 4.1: Defining digital curation | |
|--|---|
| Paper 1 | Higgins, S. (2011). <i>Digital Curation: The emergence of a new discipline</i> . The International Journal of Digital Curation, 6(2), 78–88. Retrieved from http://ijdc.net/index.php/ijdc/article/view/184/251 |
| Paper 2 | Higgins, S. (2013). Digital curation: The challenge driving convergence across memory institutions. In L. Duranti & E. Shaffer (Eds.), <i>The Memory of the World in the Digital age: Digitization and Preservation: An international conference on permanent access to digital documentary heritage</i> , Vancouver, Canada, 26-28 September 2012 (pp. 607–623). Vancouver, Canada: UNESCO. Retrieved from http://www.unesco.org/webworld/download/mow/mow_vancouver_proceedings_en.pdf |
| Paper 3 | Higgins, S., Hilton, C., & Dafis, L. L. (2014). Archives context and discovery: rethinking arrangement and description for the digital age. In <i>2nd annual conference of the International Council on Archives, 11-15 October 2014, Girona, Spain</i> . Girona. Retrieved from http://www.girona.cat/web/ica2014/ponents/textos/id174.pdf |
| Section 4.2: Developing the conceptual model | |
| Paper 4 | Higgins, S. (2007). <i>Draft DCC Curation Lifecycle Model</i> . International Journal of Digital Curation, 2(2), 82–87. Retrieved from http://ijdc.net/index.php/ijdc/article/view/46/30 |
| Paper 5 | Higgins, S. (2008). <i>The DCC Curation Lifecycle Model</i> . The International Journal of Digital Curation, 3(1), 134–140. Retrieved from http://www.ijdc.net/index.php/ijdc/article/viewFile/69/48 |
| Section 4.3: Testing and applying the conceptual model | |
| Paper 6 | Fairley, E., & Higgins, S. (2009). <i>Curated databases in the life sciences: The Edinburgh Mouse Atlas Project</i> . (A. Whyte, Ed.). Digital Curation Centre. Retrieved from http://www.dcc.ac.uk/sites/default/files/documents/scarp/SCARP_EM_AP_Final13Jul09A.pdf |
| Paper 7 | Higgins, S. (2009). DCC DIFFUSE standards frameworks. A standards path through the curation lifecycle. <i>The International Journal of Digital Curation</i> , 4(2), 60–67. Retrieved from http://www.ijdc.net/index.php/ijdc/article/viewFile/118/136 |
| Section 4.4: Elaborating the conceptual model | |
| Paper 8 | Higgins, S. (2012). The lifecycle of data management. In G. Pryor (Ed.), <i>Managing research data</i> . Facet Publishing. |
| Paper 9 | Higgins, S. (2016). Data modelling for analysis, discovery and retrieval. In A. E. Foster & P. Rafferty (Eds.), <i>Managing Digital Cultural Objects: Analysis, discovery and retrieval</i> . London, UK: Facet Publishing. |

| Section 4.5: Developing the digital curation curriculum | |
|---|--|
| Paper 10 | Bunn, J., & Higgins, S. (2013). <i>Mainstreaming Digital Curation: An overview of activity in the UK archives and records management profession</i> . In C. Cirinna, K. Fernie, & M. Lunghi (Eds.), <i>Proceedings of the Framing the Digital Curation Curriculum Conference</i> , Florence, Italy, 6-7 May, 2013. DigCurV Project. Retrieved from http://ceur-ws.org/Vol-1016/paper23.pdf |

Table A.7-1: List of submitted published works cross referenced to section

Appendix B: Pre-print text of the submitted published works

Content omitted for this online version

B.1 Paper 1: Digital Curation: The emergence of a new discipline

- Reference:** Higgins, S. (2011). *Digital Curation: The emergence of a new discipline*. The International Journal of Digital Curation, 6(2), 78–88. Retrieved from <http://ijdc.net/index.php/ijdc/article/view/184/251>
- Subject:** An analysis of digital curation's professional origins and academic beginnings.
- Reason for inclusion:** Identifies the roots of the discipline's definition

B.2 Paper 2: Digital curation: The challenge driving convergence across memory institutions

Reference: Higgins, S. (2013). Digital curation: The challenge driving convergence across memory institutions. In L. Duranti & E. Shaffer (Eds.), *The Memory of the World in the Digital age: Digitization and Preservation: An international conference on permanent access to digital documentary heritage*, Vancouver, Canada, 26-28 September 2012 (pp. 607–623). Vancouver, Canada: UNESCO. Retrieved from http://www.unesco.org/webworld/download/mow/mow_vancouver_proceedings_en.pdf

Subject: An analysis of the disciplinary space occupied by digital curation in relation to the major sub-disciplines of information science

Reason for inclusion: Identifies digital curation as a meta-discipline within information science acting as a *change agent* or disruptive innovation.

B.3 Paper 3: Archives context and discovery: rethinking arrangement and description for the digital age

Reference: Higgins, S., Hilton, C., & Dafis, L. L. (2014). Archives context and discovery: rethinking arrangement and description for the digital age. In *2nd annual conference of the International Council on Archives, 11-15 October 2014, Girona, Spain*. Girona. Retrieved from <http://www.girona.cat/web/ica2014/ponents/textos/id174.pdf>

Subject: An analysis of the disciplinary space occupied by archival science in relation to a single digital curation activity.

Reason for inclusion: Identifies digital curation as a disruptive innovation.

B.4 Paper 4: Draft DCC curation lifecycle model.

Reference: Higgins, S. (2007). *Draft DCC curation lifecycle model*. International Journal of Digital Curation, 2(2), 82–87. Retrieved from <http://ijdc.net/index.php/ijdc/article/view/46/30>

Subject: A draft version of a conceptual model for digital curation.

Reason for inclusion: Theoretically organises digital curation's conceptual space.

B.5 Paper 5: The DCC curation lifecycle model

Reference: Higgins, S. (2008). *The DCC curation lifecycle model*. The International Journal of Digital Curation, 3(1), 134–140. Retrieved from <http://www.ijdc.net/index.php/ijdc/article/viewFile/69/48>

Subject: A conceptual model for digital curation.

Reason for inclusion: Theoretically organises digital curation's conceptual space.

**B.6 Paper 6: Curated databases in the life sciences: The
Edinburgh Mouse Atlas Project.**

Reference: Fairley, E., & Higgins, S. (2009). *Curated databases in the life sciences: The Edinburgh Mouse Atlas Project*. (A. Whyte, Ed.). Digital Curation Centre. Retrieved from http://www.dcc.ac.uk/sites/default/files/documents/scarp/SCARP_EMAP_Final13Jul09A.pdf

Subject: Proof-of-concept application of a theoretical conceptual model for digital curation to professional workflow.

Reason for inclusion: Demonstrates an academic to professional feedback loop in the discipline's development.

B.7 Paper 7: DCC DIFFUSE standards frameworks. A standards path through the curation lifecycle

Reference: Higgins, S. (2009). DCC DIFFUSE standards frameworks. A standards path through the curation lifecycle. *The International Journal of Digital Curation*, 4(2), 60–67.
Retrieved from
<http://www.ijdc.net/index.php/ijdc/article/viewFile/118/136>

Subject: Proof-of-concept application of a theoretical conceptual model for digital curation to advisory services.

Reason for inclusion: Demonstrates an academic to professional feedback loop in the discipline's development.

B.8 Paper 8: The lifecycle of data management

Reference: Higgins, S. (2012). The lifecycle of data management. In G. Pryor (Ed.), *Managing research data*. Facet Publishing.

Subject: Best practice guidelines for digital curation.

Reason for inclusion: Elaborates the theoretical foundations of digital curation.

B.9 Paper 9: Data modelling for analysis, discovery and retrieval

Reference: Higgins, S. (2016). Data modelling for analysis, discovery and retrieval.
 In A. E. Foster & P. Rafferty (Eds.), *Managing Digital Cultural
 Objects: Analysis, discovery and retrieval*. London, UK: Facet
 Publishing.

Subject: Best practice guidelines for aspects of digital curation.

**Reason for
inclusion:** Elaborates the theoretical foundations of digital curation.

B.10 Paper 10: Mainstreaming Digital Curation: An overview of activity in the UK archives and records management profession

Reference: Bunn, J., & Higgins, S. (2013). *Mainstreaming Digital Curation: An overview of activity in the UK archives and records management profession*. In C. Cirinna, K. Fernie, & M. Lunghi (Eds.), *Proceedings of the Framing the Digital Curation Curriculum Conference*, Florence, Italy, 6-7 May, 2013. DigCurV Project. Retrieved from <http://ceur-ws.org/Vol-1016/paper23.pdf>

Subject: Higher education competencies for digital curation

Reason for inclusion: Identifies theoretical and experiential education for digital curation.

Appendix C: Co-author signed declarations

Content omitted for this online version

Appendix D: List of activities surrounding the published works

Content omitted for this online version

Appendix E: Curriculum Vitae

Content omitted for this online version